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Lecture 6: Design Principles & System Architecture

Course Outline

- W1: Intro ✓
- W2: Modelling with UML ✓
- W3-4: Design patterns ✓
- **W5-6: Design principles & system architecture**
- W7-8: Testing
- W9: Continuous integration
- W10: Review

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Today's Plan

- 10:05-11:55:
  - Quiz 4 (assessed, correctness)
  - Design principles
  - System architectures
  - Design in practice - revisit Lab 2
- Long break
- 13:00-14:00 OR 14:00-15:00 in BO1028: **Lab 6 - work on AE1 (tutors will be present) !**

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Quiz 6

- Join YACRS
  - Session: 1240

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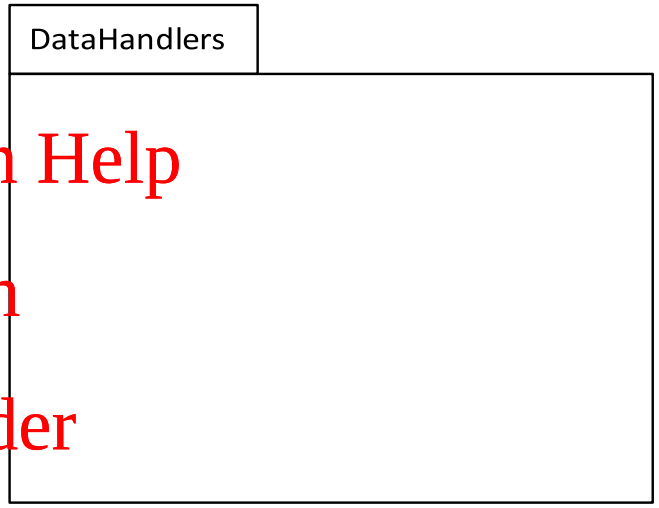
Q6.1 UML and system architecture

In UML this symbol is used to denote a:



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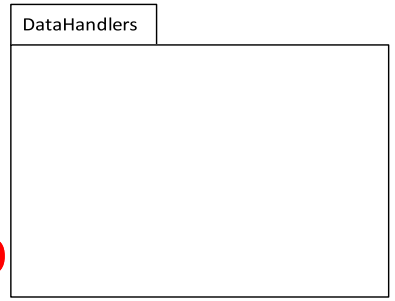
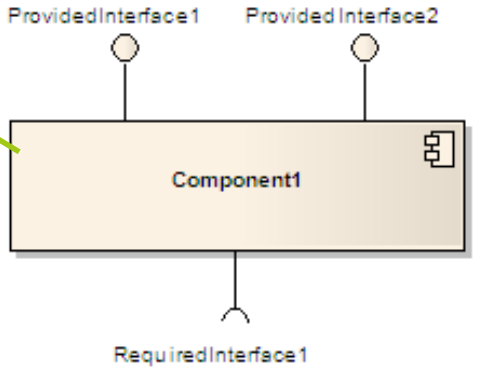
- A: package called "DataHandlers"
- B: component called "DataHandlers"
- C: class called "DataHandlers"
- D: interface called "DataHandlers"

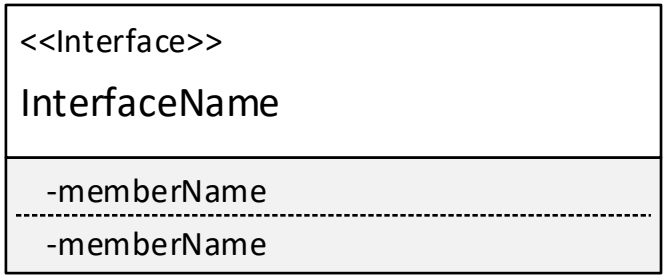
Q6.1 UML and system architecture

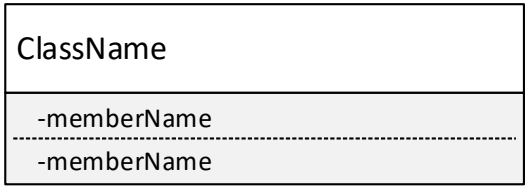
In UML this symbol is used to denote a:

- A: **package called "Datahandlers"**
- B: component called "Datahandlers"
- C: class called "Datahandlers"
- D: interface called "Datahandlers"









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Q6.2 Multi-Layer

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The multi-layer architectural pattern can (in a strict design/implementation) have dependencies in which direction(s)?

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- A: Any connection / dependency between layers is allowed
- B: Higher layers depend on lower layers
- C: Both ways
- D: Lower layers depend on higher layers

Q6.2 Multi-Layer (solution)

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The multi-layer architectural pattern can (in a strict design/implementation) have dependencies in which direction(s)?

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- A: Any connection / dependency between layers is allowed
- B: **Higher layers depend on lower layers**
- C: Both ways
- D: Lower layers depend on higher layers

Q6.3 Architectures

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Consider the following scenario. The system includes a user interface, which must interact with a local database. The user interface is accessed from a mobile device.

Which architectures is most suitable in this scenario?

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- A: Broker pattern
- B: Model View Controller pattern
- C: Pipe and filter pattern
- D: Transaction processing pattern

Q6.3 Architectures (solution)

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Consider the following scenario. The system includes a user interface, which must interact with a **local** database. The user interface is accessed from a mobile device.

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Which architectures is most suitable to use in this scenario?

- A: Broker architectural pattern
- B: **Model View Controller**
- C: Pipe and filter
- D: Transaction processing

Design

Properties of "good" design:

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- Increasing profit by reducing cost or increasing revenue
- Ensuring that we actually conform with the requirements
- Accelerating development
- Increasing qualities such as
  - Usability
  - Efficiency
  - Reliability
  - Maintainability
  - Reusability
  - …

DESIGN Principles

- Divide and Conquer
- Cohesion
- Coupling
- Keep the level of abstraction as high as possible (already covered)
- Increase reusability
- Reuse existing designs and code
- Anticipate obsolescence
- Design for portability
- Design for testability
- Design defensively

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Divide and conquer (combine)

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- Trying to deal with something big all at once is normally much harder than dealing with a series of smaller things

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  - Separate people can work on each part.
  - An individual software engineer can specialize.

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  - Each individual component is smaller, and therefore easier to understand.
  - Parts can be replaced or changed without having to replace or extensively change other parts.

Cohesion: High cohesion is good

- Functional
- Layer
- Communicational
- Sequential
- Procedural
- Temporal
- Utility

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Coupling: High Coupling is Bad

- Content
- Common
- Control
- Data
- Routine
- Type Use
- Import
- External

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Abstraction level should be as high AS possible

- Keeping the level of abstraction high means being able to understand or use the system without knowing and understanding specific details.

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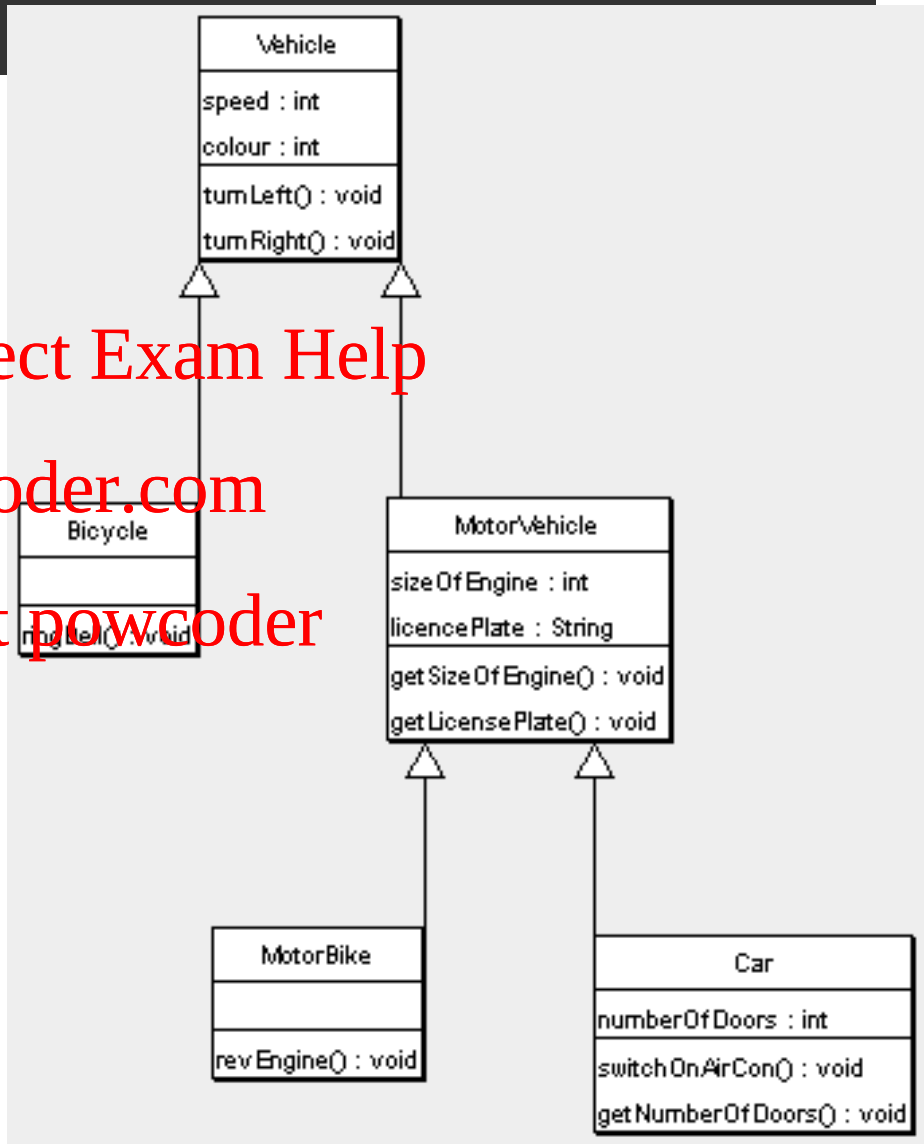

Increase Reusability Where Possible

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- Design the various aspects of your system so that they can be used again in other contexts
  - Generalize your design as much as possible (abstraction)
  - Ensure cohesion and low coupling
  - Design your system to contain hooks

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- Hooks: Which design patterns provide hooks, and how does this help promote reusability?

Increase Reusability through Hooks

- The Factory Pattern allows programmers to add their own classes into an existing hierarchy, and dynamically setting a custom factory provides a powerful hook to extend the Factory Framework.

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Reuse existing Designs and Code Where Possible

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- (Good) designs and code should be reused.

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- Why is cloning not considered a good way of reusing code? What side effects does cloning have?

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Cloning is Not Reuse

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- Copy and Paste is abolished in software engineering.
- If a library changes, your clone may not be updated.
- Local code can be changed, which makes maintainability more difficult.
- Unless you have an infrastructure to update your clone (for example using networked version control) a clone is not a good way to reuse code.
- **Unless there is some other need to keep a local copy for reliability reasons. See Tolerating Clones? Page 331.**

Design for Flexibility

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- Actively anticipate changes that a design may have to undergo in the future, and prepare for them
  - Reduce coupling and increase cohesion
  - Create abstractions
  - Do not hard code anything
  - Leave all options open
    - Do not restrict the options of people who have to modify the system later
  - Use reusable code and make code reusable
- Identify an alternative to hard coded constraints and how you would implement this alternative in Java?

Anticipate Obsolescence

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- Anticipating obsolescence is an important design principle, but may contradict other design principles.

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- Which other design principles play a role in anticipating obsolescence, and how would you balance these concerns?

Anticipate Obsolescence

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- Reusing code can be in direct competition with anticipating obsolescence.
- A library or package may cease to be maintained by the library producer, then you are stuck with a legacy dependency.
- If different parts of a library are not well maintained or implemented, your dependence on them becomes more volatile.
- **For example**, OpenCV is a library with a wide variety of quality in its modules. Dependence on a more experimental module is more risky.

Design for portability

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- Designing for portability means designing so that your software can be run on as many platforms as possible.
- One field where this is particularly difficult is mobile platforms where standardization is limited, and platforms specifically compete for business by providing different features.
- For example, let's say you want to design a mobile application that requires an NFC sensor to function properly. What trade-offs must you consider when deciding to use NFC features or not?

Example: NFC and Portability

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- How likely is it that many platforms will support NFC hardware?

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- What market forces will influence the continued support for NFC?

- What will happen if a user downloads this app but doesn't have the correct hardware?

Design for Testability

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- Take steps to make testing easier
  - Design a program to automatically test the software
    - Discussed more in Chapter 16
    - Ensure that all the functionality of the code can by driven by an external program, bypassing a graphical user interface
  - In Java, you can create a main() method in each class in order to exercise the other methods
- E.g. the Model View Controller is on way of dividing and organizing a system architecture. How does the architecture help or hinder designing for testability?

Design for Testability

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- Model View Controller separates functionality from a GUI, but designing for testability goes one step further and provides methods for running all GUI functions either through additional main methods or through a command line interface.

- If functionality is coupled to GUI actions, it can be costly and time consuming to run testing. Large scale testing would not be practical if testers had to run tests through the application GUI.

Design Defensively

- Not only must you be able to produce code without errors, you should attempt to make your code robust enough that other users of your class can't introduce errors.

How might you refactor this code to design more defensively?

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```
//  This is snippet from a Course class.
//  A student can be enrolled in a Course, but the ID
// number must be valid

public void enrollStudent(int studentID) {
        this.addStudent(studentID);
}
```

Design Defensively

```
//  This is snippet from a Course class.
//  A student can be enrolled in a Course, but the ID number
// must be valid
public boolean enrollStudent(int studentID) {

        if (checkStudentIDValid(studentID)) {
                this.addStudent(studentID);
                return true;
        }
        else {
                return false;
        }
}
```

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Software Architecture

Software Architecture

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- *Software architecture* is process of designing the **global** organization of a software system, including:
  - Dividing software into subsystems.
  - Deciding how these will interact.
  - Determining their interfaces.
    - The architecture is the core of the design, so all software engineers need to understand it.
    - The architecture will often constrain the overall efficiency, reusability and maintainability of the system.

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Architectural Models Support Good Design

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- Enable everyone to better understand the system
- To allow people to work on individual pieces of the system in isolation

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- To prepare for extension of the system
- To facilitate reuse and reusability

UML for System level modelling

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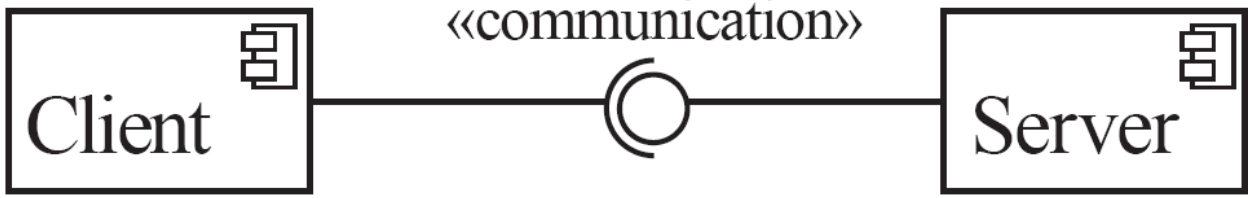

Deployment diagrams

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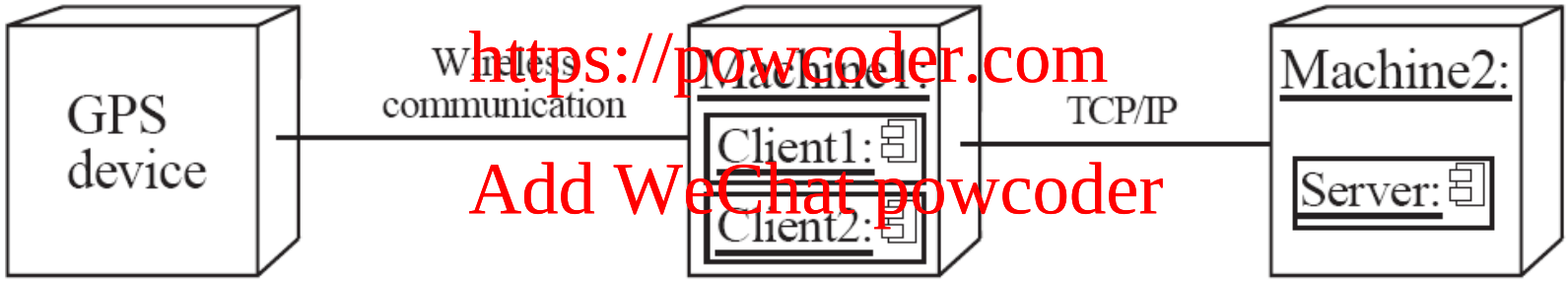
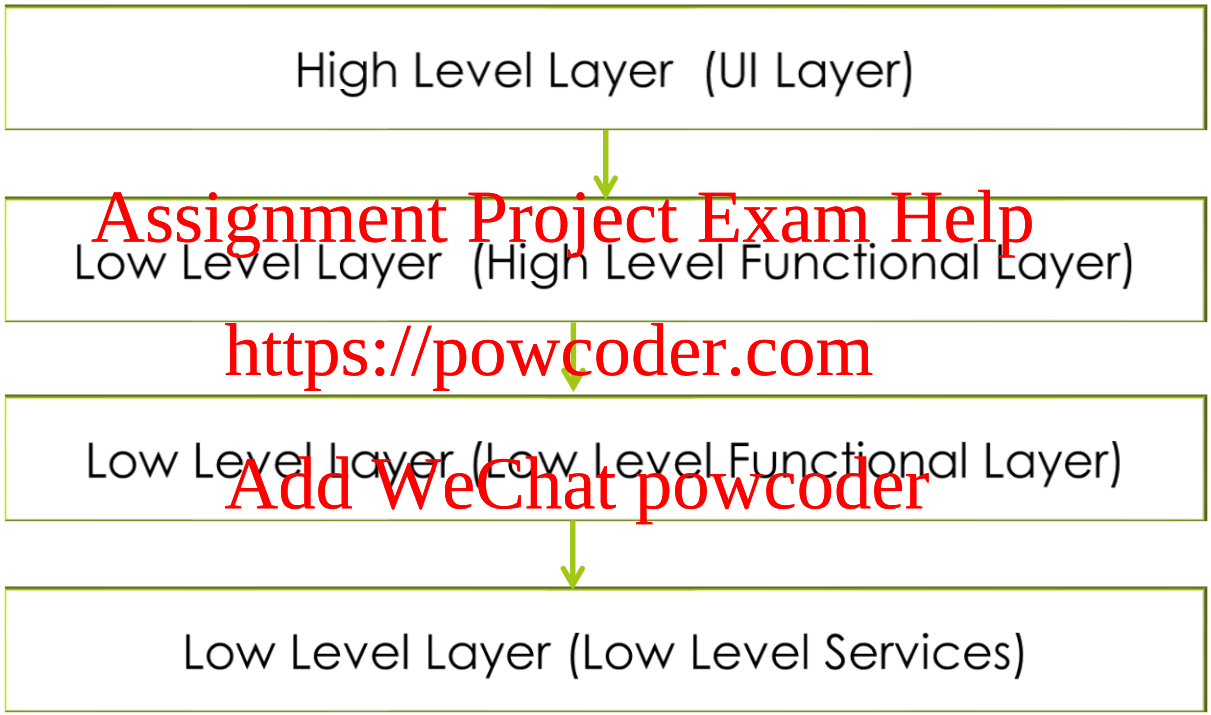


MultiLayer Architecture



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An abstract example multilayer architecture.
Actual implementations vary….

Multilayer Implementation I

A simple implementation with procedures:

- Demo: mylayered.app.Java

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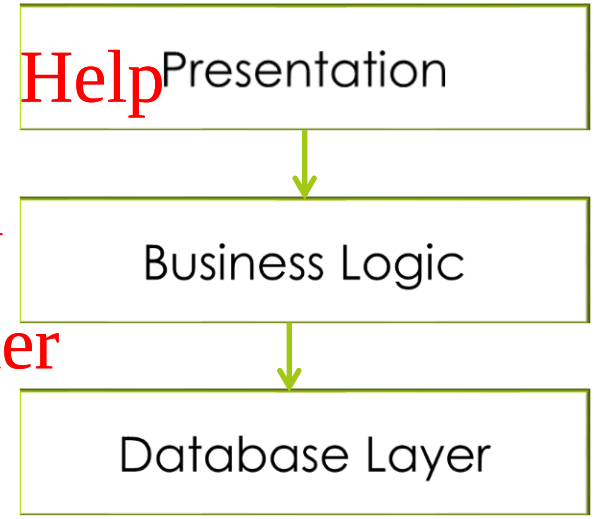

Relaxed multi layer architecture

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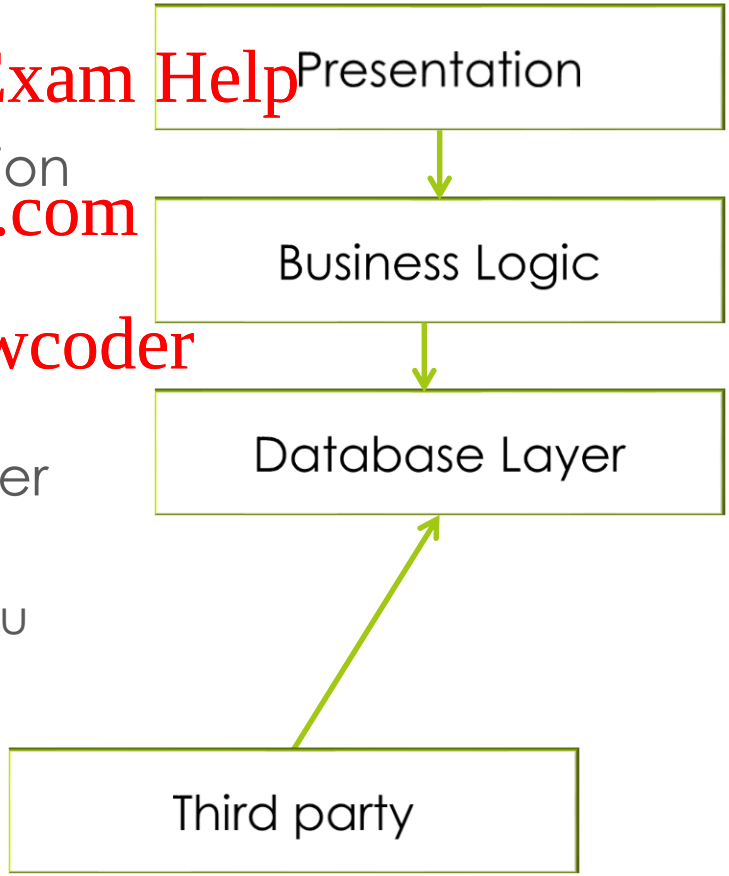
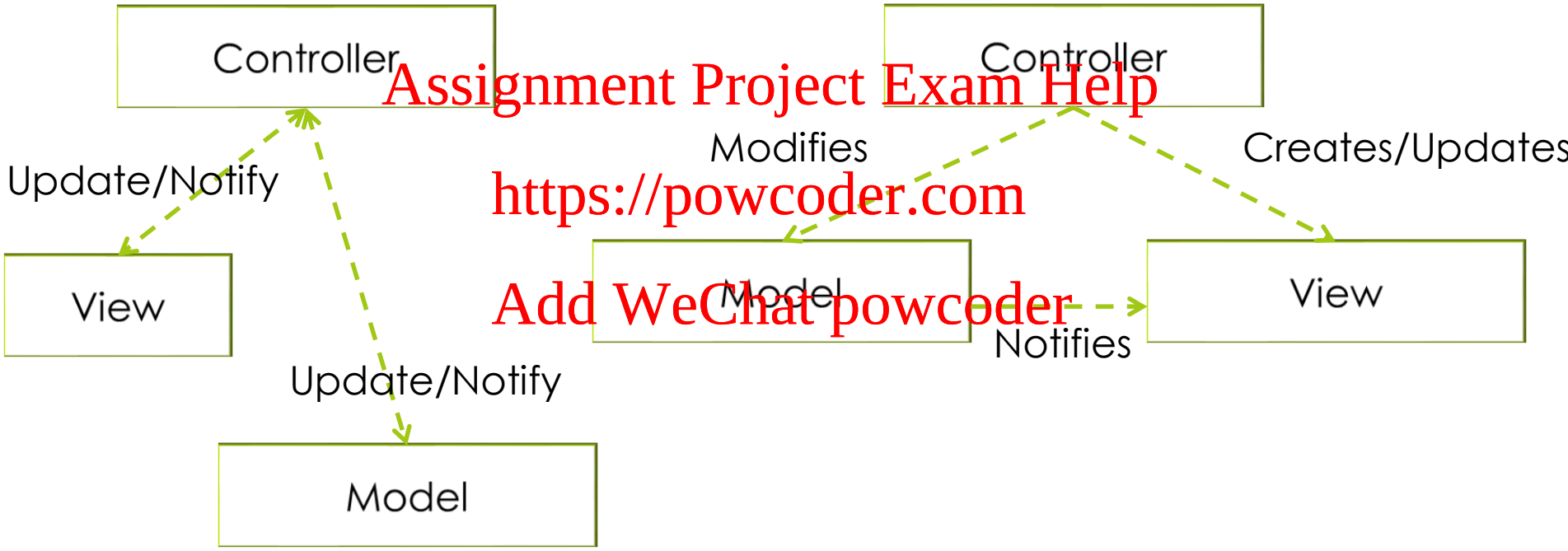
- What happens if the database changes without the Presentation layer knowing?
- Can we come up with an implementation with minimum coupling that allow a lower layer to indicate a change ?
  - Which design pattern would you use ?



Model View Controller



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Client Server

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Transaction-Processing

- A process reads a series of inputs one by one.
  - Each input describes a *transaction* – a command that typically some change to the data stored by the system
  - There is a transaction dispatcher component that decides what to do with each transaction
  - This dispatches a procedure call or message to one of a series of component that will *handle* the transaction

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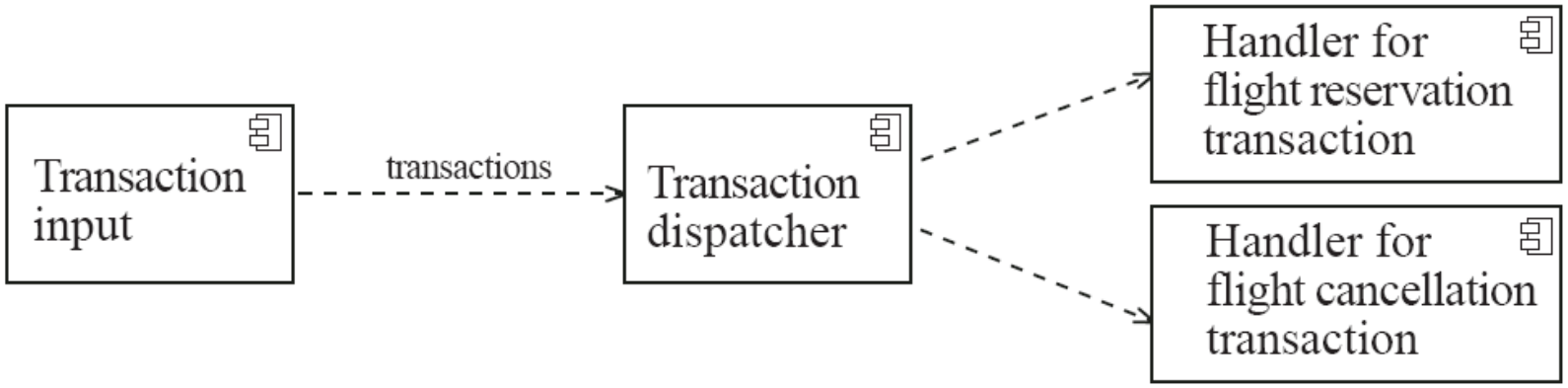

Pipe-and-Filter

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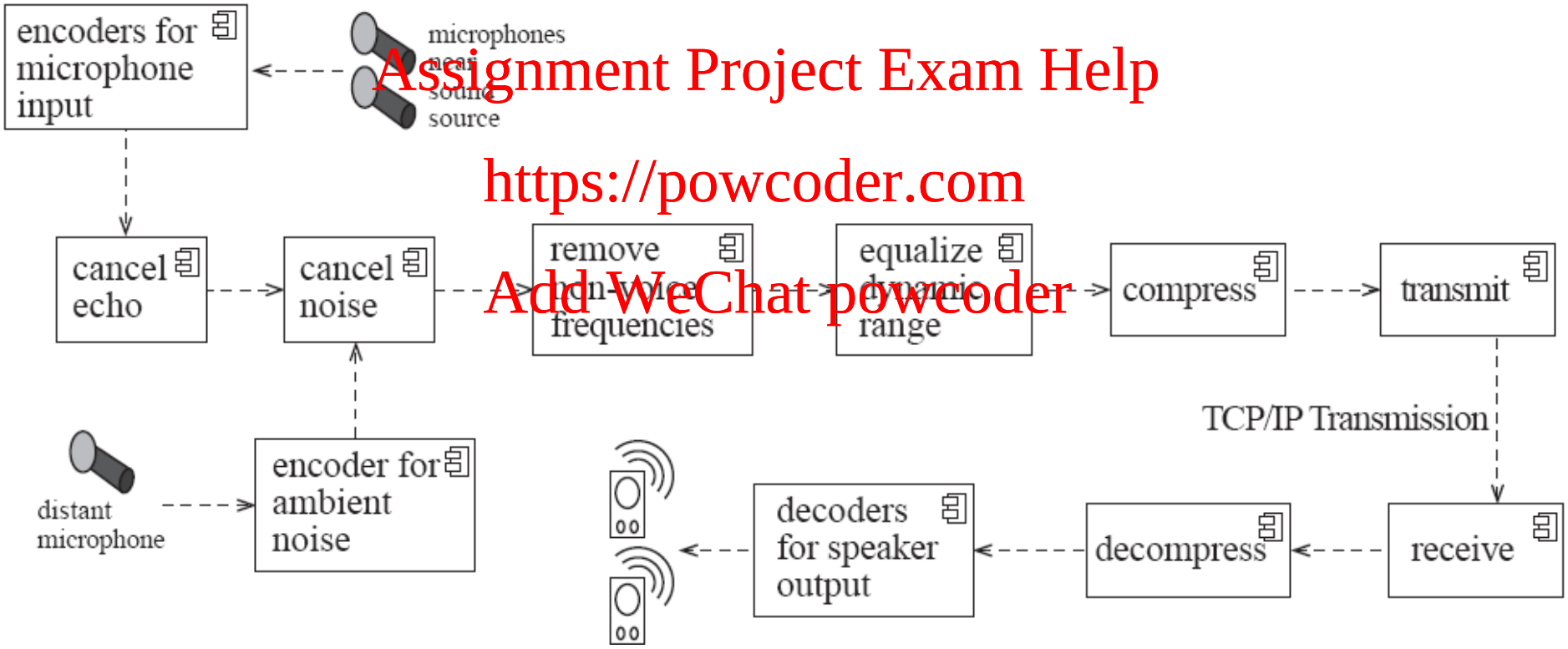
- A stream of data, in a relatively simple format, is passed through a series of processes
  - Each of which transforms it in some way.
  - Data is constantly fed into the pipeline.
  - The processes work concurrently.
  - The architecture is very flexible.
    - Almost all the components could be removed.
    - Components could be replaced.
    - New components could be inserted.
    - Certain components could be reordered.

Example: Pipe-and-Filter



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Others…

- Service oriented

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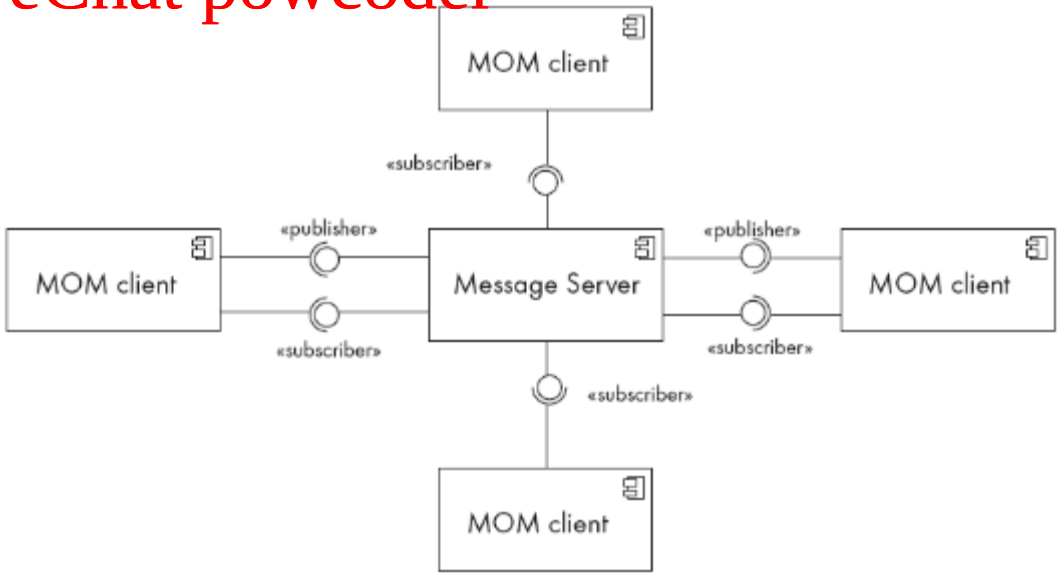
- Message oriented



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In practise..

Making design decisions

- Using priorities and objectives to decide among alternatives
  - Step 1: List and describe the alternatives for the design decision.
  - Step 2: List the advantages and disadvantages of each alternative with respect to your objectives and priorities.
  - Step 3: Determine whether any of the alternatives prevents you from meeting one or more of the objectives.
  - Step 4: Choose the alternative that helps you to best meet your objectives.
  - Step 5: Adjust priorities for subsequent decision making.

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Cost-benefit analysis

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- To estimate the *costs*, add up:
  - The incremental cost of doing the *software engineering* work, including ongoing maintenance
  - The incremental costs of any *development technology* required
  - The incremental costs that *end-users and product support personnel* will experience
- To estimate the *benefits*, add up:
  - The incremental software engineering time saved
  - The incremental benefits measured in terms of either ***increased sales or other financial benefits*** to users

Design documentation

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- Design documents as an aid to making better designs
  - They force you to be explicit and consider the important issues before starting implementation.
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  - They allow a group of people to review the design and therefore to improve it.
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  - Design documents as a means of communication.
    - To those who will be *implementing* the design.
    - To those who will need, in the future, to *modify* the design.
    - To those who need to create systems or subsystems that *interface* with the system being designed.

Documentation

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A. Purpose:
- What system or part of the system this design document describes.
- Make reference to the requirements that are being implemented by this design (*traceability*).

B. General priorities:
- Describe the priorities used to guide the design process.

C. Outline of the design:
- Give a high-level description of the design that allows the reader to quickly get a general feeling for it.

D. Major design issues:
- Discuss the important issues that had to be resolved.
- Give the possible alternatives that were considered, the final decision and the rationale for the decision.

E. Other details of the design:
- Give any other details the reader may want to know that have not yet been mentioned.

Documentation: Javadoc

- The audience for JavaDoc is Java developers

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```
/**
 * Returns an Image object that can then be painted on the screen.
 * The url argument must specify an absolute {@link URL}. The name
 * argument is a specifier that is relative to the url argument.
 * <p>
 * This method always returns immediately, whether or not the
 * image exists. When this applet attempts to draw the image on
 * the screen, the data will be loaded. The graphics primitives
 * that draw the image will incrementally paint on the screen.
 *
 * @param  url  an absolute URL giving the base location of the image
 * @param  name the location of the image, relative to the url argument
 * @return      the image at the specified URL
 * @see         Image
 */
public Image getImage(URL url, String name) {
        try {
            return getImage(new URL(url, name));
        } catch (MalformedURLException e) {
            return null;
        }
}
```

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getImage

```
public Image getImage(URL url,
                      String name)
```

Returns an `Image` object that can then be painted on the screen. The `url` argument must specify an absolute URL. The `name` argument is a specifier that is relative to the `url` argument.

This method always returns immediately, whether or not the image exists. When this applet attempts to draw the image on the screen, the data will be loaded. The graphics primitives that draw the image will incrementally paint on the screen.

Parameters:

`url` - an absolute URL giving the base location of the image.

`name` - the location of the image, relative to the `url` argument.

Returns:

the image at the specified URL.

See Also:

`Image`

Keywords

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- @author (classes and interfaces only, required)
- @version (classes and interfaces only, required. See footnote 1)
- @param (methods and constructors only)
- @return (methods only)
- @exception (@throws is a synonym added in Javadoc 1.2)
- @see
- @since
- @serial (or @serialField or @serialData)
- @deprecated (see How and When To Deprecate APIs)

Full JavaDoc Overview

- http://www.oracle.com/technetwork/articles/java/index-137868.html

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Design in practise - revisit Lab 2

User Requirements to Design

- A software for a travel agency provide reservations facilities for the people who whish to travel on tours by accessing a built-in network at the agency bureau.
- The application software keeps information on all the tours.
- Users can access the system to make a reservation on a tour and to view information about the tours available online.
- Users can access the system to cancel a reservation the he/she has made.
- Any complaints or suggestions that the client may have could be sent by email to the agency or stored in a complaint database.
- The employees of the corresponding agency could use the application to administrate the systems operations. Employees can add, delete, and update the information on the customers and the tours.
- For security purposes, the employee should be provided a login ID and password by the manager to be able to access the database of the travel agency.

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User Requirements to UML

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- Users can access the system to cancel a reservation the he/she has made.
- Any complaints or suggestions that the client may have could be sent by email to the agency or stored in a complaint database.
- The employees of the corresponding agency could use the application to administrate the systems operations. Employees can add, delete, and update the information on the customers and the tours.
- For security purposes, the employee should be provided a login ID and password by the manager to be able to access the database of the travel agency.

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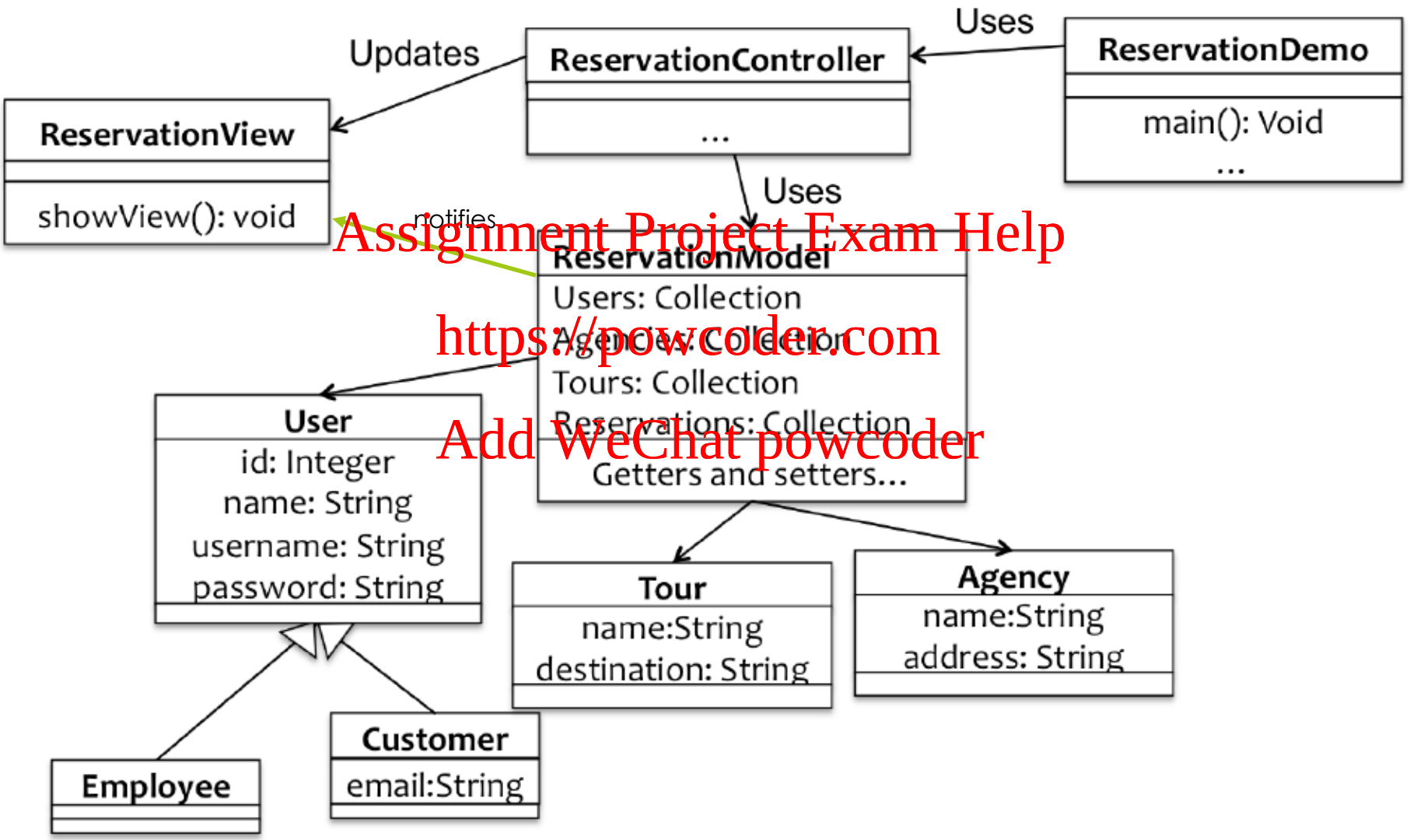
Model solution (high level)



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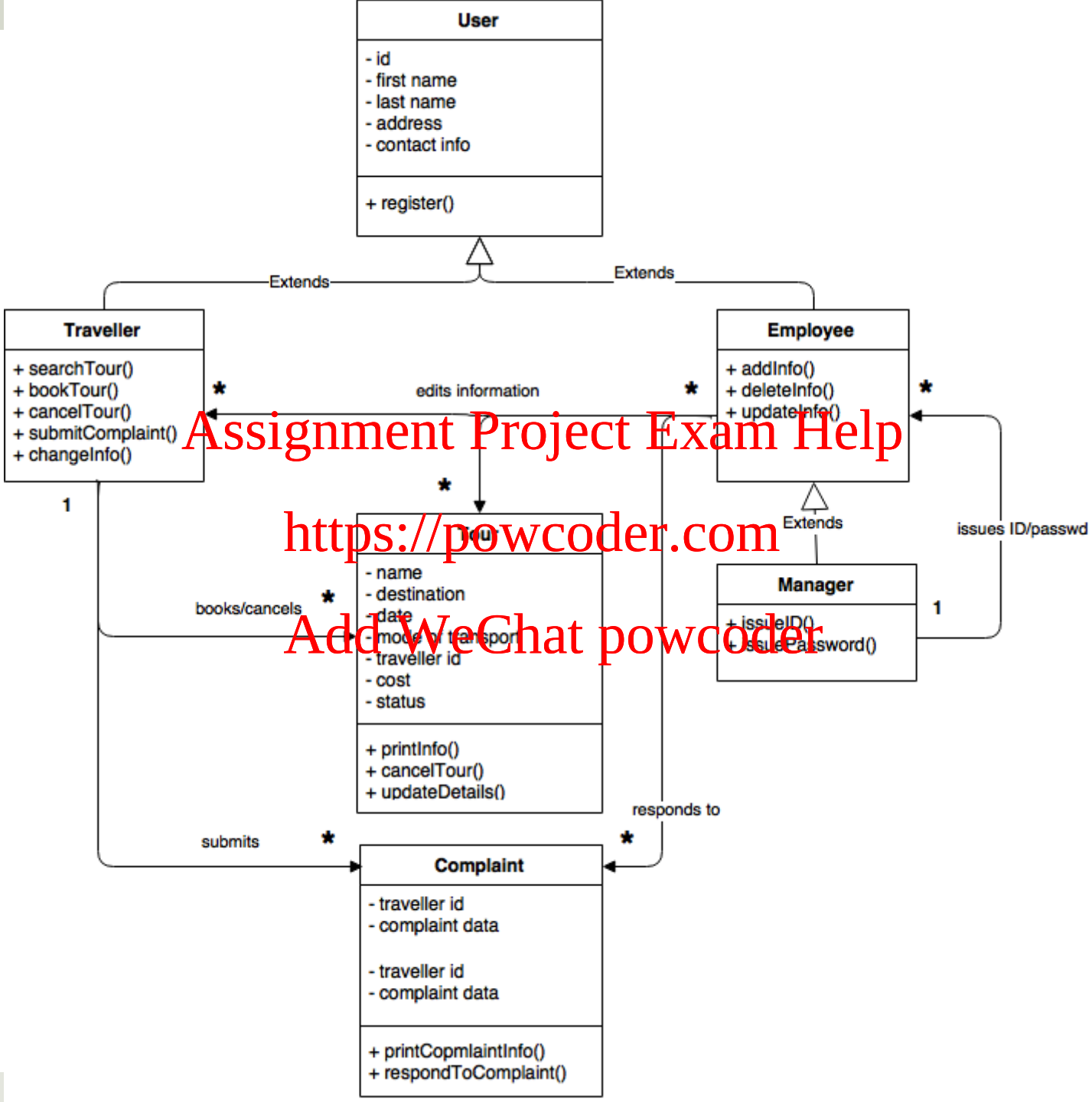

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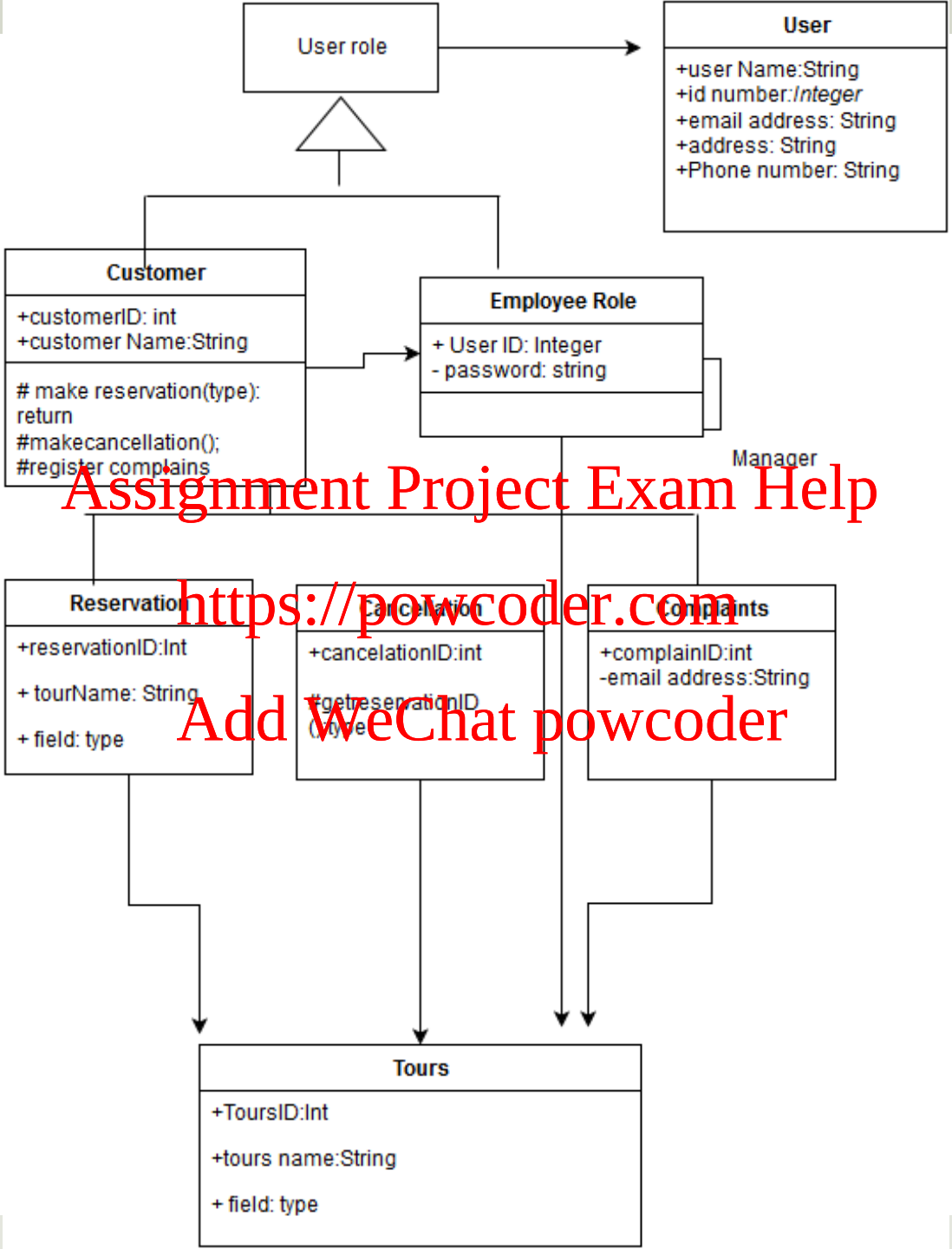

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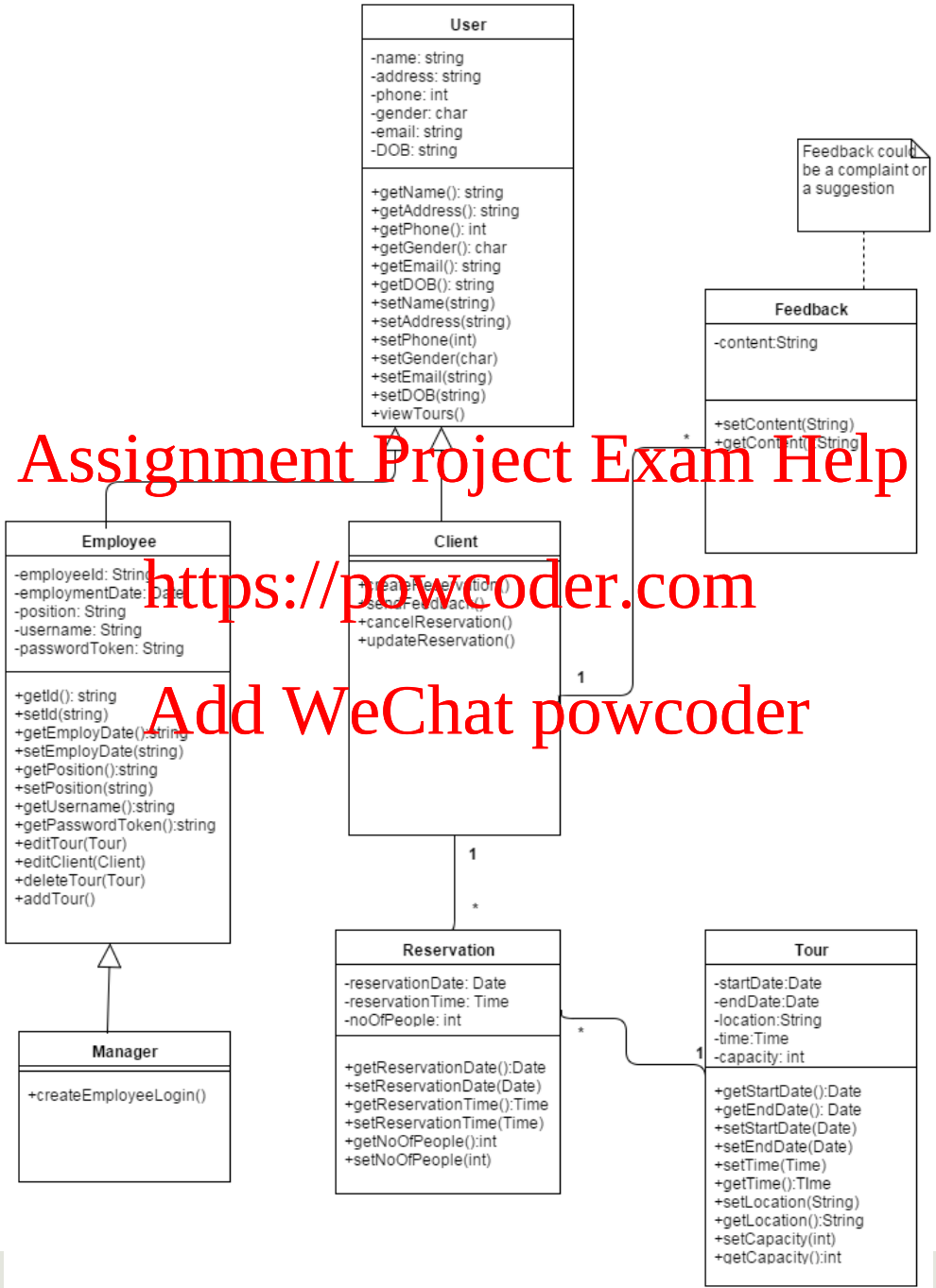
Online Reservations Case Study UML Diagram



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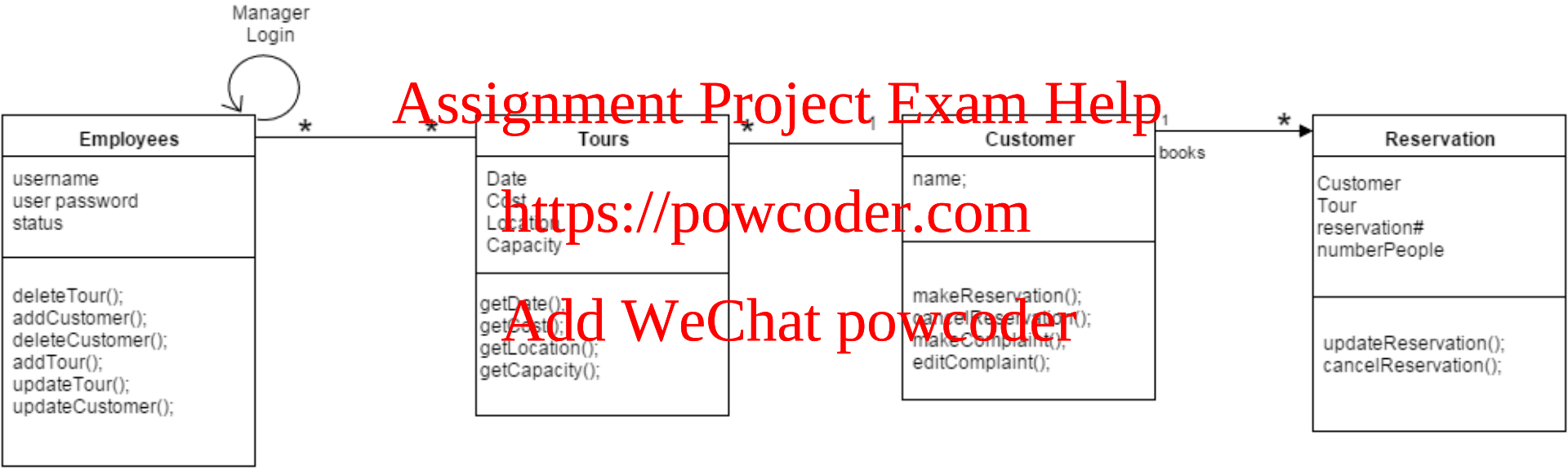

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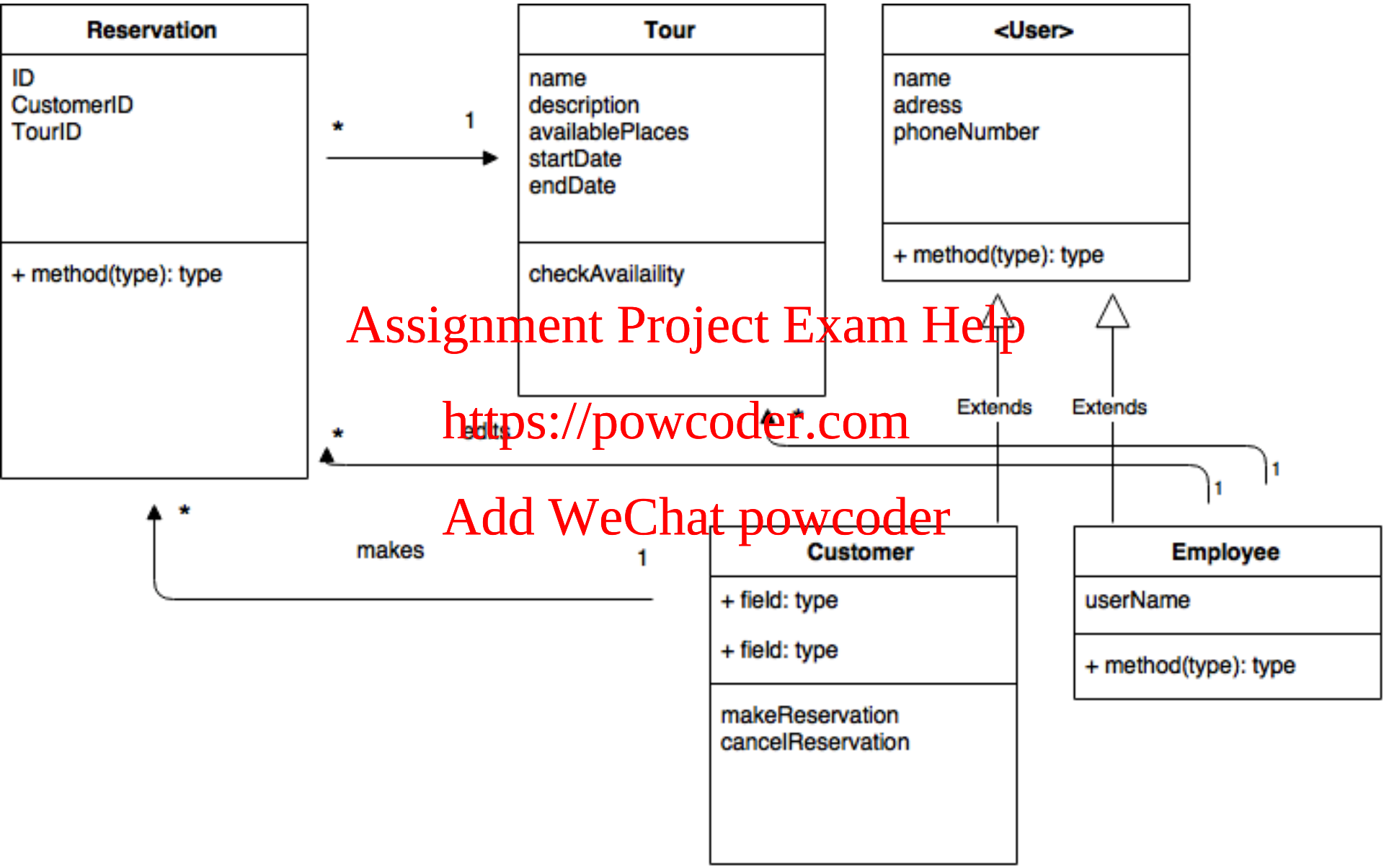

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Consensus

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Summary

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- Design process
  - Analysis & Modelling (domain vs system)
  - Design patterns
  - Design principles
  - Architectural patterns
  - Documentation

  Assumptions and trade-offs among priorities are required and ubiquitous – make sure to provide explanation and rationale for MAJOR decisions.

- Lab 6 at 13:00 or 14:00 in BO1028

Next Week

- Testing
- Read: OOSE Chapter 10

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