SFWR ENG 3A04: Software Design II

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Term 1, 2008–2009

Acknowledgments: Material based on *Software Architecture Design* by Tao et al. (Chapter 4)

Outline of Part I

1. UML for Software Architecture

2. Questions???

Outline of Part II

3 Overview

4 OO Analysis and Design
- OO Analysis
- OO Design

Part I

Review of Previous Lecture

Part II

Today's Lecture

OO Analysis and Design Overview

- The Object Oriented (OO) architecture style emerged from the conceptualization of abstract data types (ADT)

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- An abstract data type is the specification of a set of logically correlated data items, and the operations that can be performed on them
- string, tree, and vector can be regarded as ADT
- The use of ADT allows separation of interface and implementation
- There can be various concrete implementations for a same ADT

OO Analysis and Design Overview

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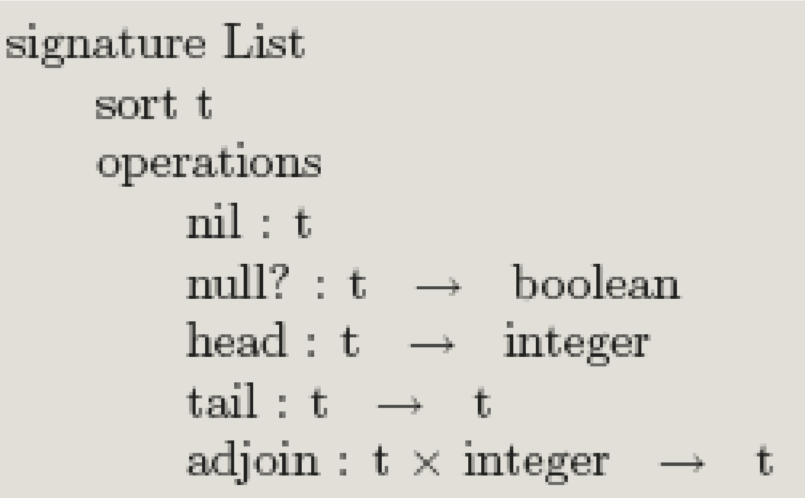
OO Analysis and Design Overview



```
signature List
    sort t
    operations
        nil : t
        null? : t  →  boolean
        head : t  →  integer
        tail : t  →  t
        adjoin : t × integer  →  t
```

Overview

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- Such separation (due to abstraction) allows great flexibility in software analysis, design, and development
- Senior software analysts and architects can concentrate on the abstract and logical design of the system
- Programmers can furnish the details of each component in its implementation
- Result: greatly reduces the complexity of software development and help to increase the reliability of the whole system

OO Analysis and Design Overview

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- Inheritance:
    - Programmers can define derived classes from base classes to inherit existing attributes and operations
    - Allows re-using existing software components (cost)

OO Analysis and Design Overview

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Overview

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OO Analysis and Design Overview

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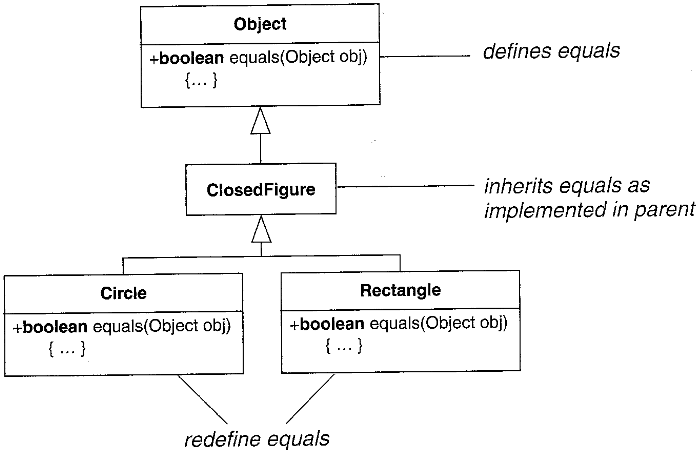
  - Refers to the ability of an object to behave differently and assume many different forms
  - Includes vertical override operations between parent classes and derived classes
  - Includes horizontal overloading operations within the same class


Object
+boolean equals(Object obj)
{… }
defines equals
ClosedFigure
inherits equals as implemented in parent
Circle
+boolean equals(Object obj)
{ … }
Rectangle
+boolean equals(Object obj)
{ … }
redefine equals

Overview

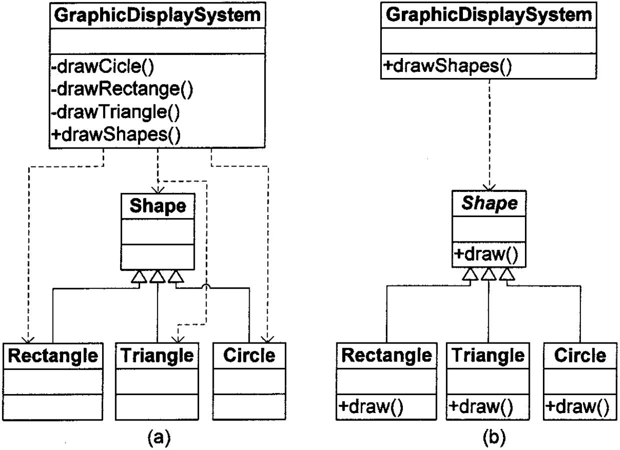


Figure: Vertical override operation (Used for decoupling)

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OO Analysis and Design Overview

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OO Analysis and Design   Overview

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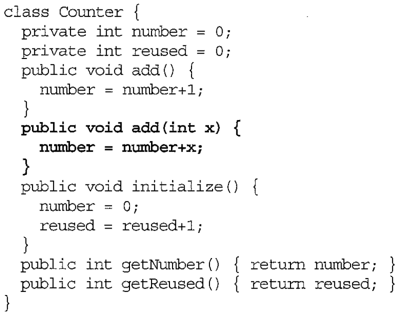
- Polymorphism (Continued):
  - Includes horizontal overloading operations within the same class
    - Attribute names of a class may be the same as those in another class since they are accessed independently (different scopes)
    - Within a Java class construct, methods may share the same name as long as they may be distinguished either by the number of parameters, or different parameter types (signature)

OO Analysis and Design Overview



```
class Counter {
  private int number = 0;
  private int reused = 0;
  public void add() {
    number = number+1;
  }
  public void add(int x) {
    number = number+x;
  }
  public void initialize() {
    number = 0;
    reused = reused+1;
  }
  public int getNumber() { return number; }
  public int getReused() { return reused; }
}
```

Figure: Horizontal overloading operation

OO Analysis and Design OO Analysis and Design

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OO Analysis and Design

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OO Analysis and Design

- Generally, an OO development process has three stages:
  1. OO analysis
  2. OO design
  3. OO implementation
- To illustrate this process, we are going to use an Order Processing System (OPS)

OO Analysis and Design

- (RI) Each customer has an online shopping cart, which allows addition and removal of items.
- (R2) A customer is able to check out the shopping cart using credit card. The transaction is approved only when the financial department has verified the validity and the remaining credit line of the credit card.
- (RJ) Before the transaction is completed, a customer should be able to learn about the estimated arrival date, which is determined by the order processing time of the shipping department.
- (R4) A customer can choose to cancel the transaction by clearing all items of the cart.
- (R5) OPS must be available as a Web accessible system. Customers can use popular Internet browsers to interact with OPS.

OO Analysis and Design
(OO Analysis)

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- OO analysis mainly relies on two UML tools:
  - UML Use Case Diagram ⟸ Reqts
  - Analysis Class Diagram ⟸ Design

OO Analysis and Design
(OO Analysis)
STEP 1: Use Case Diagram

- Register: A customer visits the registration page, and specifies the desired user name and password. If there is already such a username/password pair, the system reports error; otherwise, it reports success. When the registration is completed, the user name, password, real name, and the billing address are stored in a database system.

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STEP 1: Use Case Diagram

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- Session: When a customer logs on using correct user name and password, the customer starts a session. During the session, the system maintains a shopping cart for the user, which records the list of desired items that the customer wants to purchase later. The session is terminated either because the user checks out the shopping cart, logs out of the system, or times out. A session consists of a list of operations.

OO Analysis and Design
(OO Analysis)
STEP 1: Use Case Diagram (Continued)

- Operation: The operation use case is an abstract use case. It is extended by login, logout, add item, remove item, clear cart, and check out.

OO Analysis and Design
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STEP 1: Use Case Diagram (Continued)

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OO Analysis and Design
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- Log in: It is always the first operation of any session. When the supplied user name and password are correct, the session starts. A maximum number of 3 trials are allowed for each user. When a user fails more than 3 times, the account is locked.
- Log out: When the customer has not checked out all the items of the shopping cart, the shopping cart is saved in the database so that at the beginning of the next logs on, the shopping cart is loaded with the items of the last session.

OO Analysis and Design
(OO Analysis)
STEP 1: Use Case Diagram (Continued)

- Add item: Add the item into the shopping cart. Before the item is added, the catalog and inventory database should be checked to verify availability of the item, and the cost and price information of the item.

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- Clear shopping cart: Remove all items from the chart.
- Check out: Ask the user to input credit card information, send the information to financial department for verification. If the transaction is approved, the credit card is charged; if not, prompts the user that the check out process has failed, and the items still remain in the cart. When trans. is successful, instructions are sent to shipping department.

OO Analysis and Design
(OO Analysis)
STEP 1: Use Case Diagram (Continued)

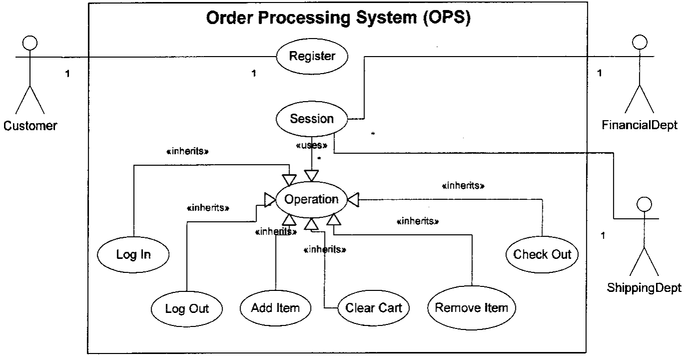

Figure: Use case diagram of the OPS system

OO Analysis and Design
(OO Analysis)
STEP 1: Use Case Diagram (Continued)

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OO Analysis and Design
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OO Analysis and Design
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- Usually in an OO design, each use case is monitored by a controller class, especially when the use case has a long duration flow of events
- Sometimes, a use case can be modeled as an operation, if its logic is not complex
- How to develop an analysis class diagram based on the information we have obtained during the requirement analysis?

OO Analysis and Design
(OO Analysis)
STEP 2: Develop Analysis Class Diagram

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- An analysis class diagram describes the functionality of the system

- It is an abstract model of the system by abstracting out the design details (overall architecture)

- The class diagram will be further refined and the relationship among the classes might be changed (add Nonfunctional Rqts)

OO Analysis and Design
(OO Analysis)
STEP 2: Develop Analysis Class Diagram

There are three types of classes:

- Boundary classes:

OO Analysis and Design
(OO Analysis)
STEP 2: Develop Analysis Class Diagram

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OO Analysis and Design
(OO Analysis)
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OO Analysis and Design (OO Analysis) STEP 2: Develop Analysis Class Diagram

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    - Coordinates the interactions that are required to accomplish the use case
    - Are event handlers

OO Analysis and Design
(OO Analysis)
STEP 2: Develop Analysis Class Diagram

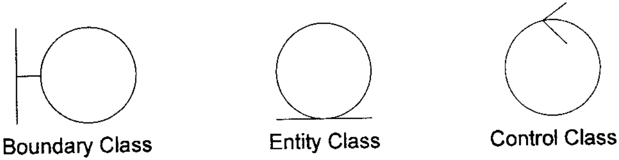

Figure: Three types of classes in an analysis class diagram

STEP 2: Develop Analysis Class Diagram

- How to identify classes which constitute the system first?

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OO Analysis and Design
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OO Analysis and Design
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- Nouns are candidates of classes
- Verbs are candidates of their functions

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OO Analysis and Design
(OO Analysis)
STEP 2: Develop Analysis Class Diagram

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OO Analysis and Design
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OO Analysis and Design
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OO Analysis and Design

(OO Analysis)

STEP 2: Develop Analysis Class Diagram

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- password: No (an attribute of another class: CustomerIdentit)
- username/password pair: Yes (should be modeled as CustomerIdentity class)

OO Analysis and Design
(OO Analysis)
STEP 2: Develop Analysis Class Diagram

- system:

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(OO Analysis)
STEP 2: Develop Analysis Class Diagram

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OO Analysis and Design
(OO Analysis)
STEP 2: Develop Analysis Class Diagram

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OO Analysis and Design
(OO Analysis)
STEP 2: Develop Analysis Class Diagram

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OO Analysis and Design
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- success: $\Longrightarrow$ RegistrationSuccessPage (boundary class)

- registration:
  - refers to the registration process
  - leads to the creation of controller class named RegistrationController for this use case

OO Analysis and Design (OO Analysis) STEP 2: Develop Analysis Class Diagram

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OO Analysis and Design
(OO Analysis)
STEP 2: Develop Analysis Class Diagram

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OO Analysis and Design
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STEP 2: Develop Analysis Class Diagram

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OO Analysis and Design
(OO Analysis)
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STEP 2: Develop Analysis Class Diagram

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OO Analysis and Design
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STEP 2: Develop Analysis Class Diagram

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- database system:
  - we can infer that there are catalog and inventory database systems out of the scope of OPS
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  - a wrapper class (i.e., boundary class) called CustomerInfoDB should be created to interact with the database

OO Analysis and Design
(OO Analysis)
STEP 2: Develop Analysis Class Diagram

We obtain:

- RegistrationPage: a boundary class for registration

OO Analysis and Design
(OO Analysis)
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OO Analysis and Design
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- RegistrationPage: a boundary class for registration
- RegistrationErrorPage: a boundary class for reporting registration error
- RegistrationSuccessPage: a boundary class for concluding the registration process
- Customer/identity: an entity class which records the user name and password of a customer

OO Analysis and Design
(OO Analysis)
STEP 2: Develop Analysis Class Diagram

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OO Analysis and Design
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OO Analysis and Design
(OO Analysis)
STEP 2: Develop Analysis Class Diagram

- CustomerInfomation: an entity class which records the information of a customer, e.g., his/her CustomerIdentity, real name, and billing address
- CustomerInfoDB: a boundary class which manipulates the customer information database
- RegistrationController: a controller class which coordinates the registration process. The class is responsible for, e.g., , redirecting from the RegistrationPage to RegistrationSuccessPage if the registration is completed successfully

OO Analysis and Design
(OO Analysis)
STEP 2: Develop Analysis Class Diagram

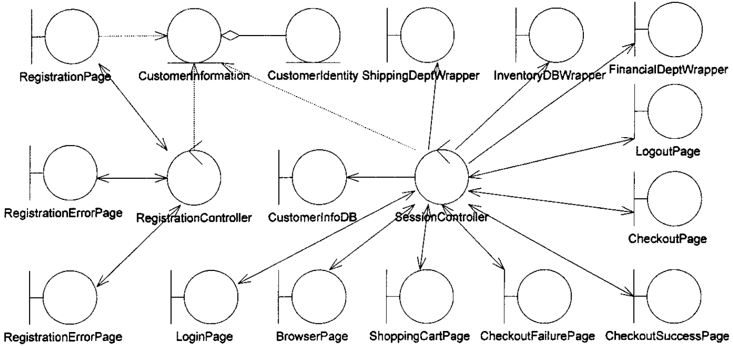

Figure: Analysis class diagram of OPS

OO Analysis and Design (OO Design)

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OO Analysis and Design
(OO Design)

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OO Analysis and Design
(OO Design)

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OO Analysis and Design (OO Design)

STEP 1: Identify all Classes

- Analysis class diagram presents the rough logical structure of the system

OO Analysis and Design
(OO Design)
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OO Analysis and Design (OO Design)

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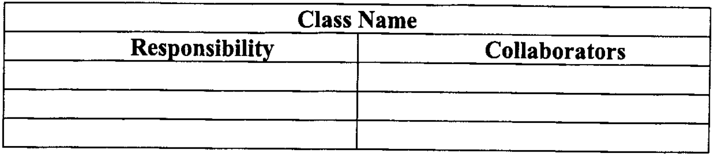

Class Name	
Responsibility	Collaborators

Figure: CRC card template

OO Analysis and Design
(OO Design)
STEP 1: Identify all Classes

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OO Analysis and Design
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OO Analysis and Design
(OO Design)
STEP 1: Identify all Classes

How to play CRC cards?

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OO Analysis and Design
(OO Design)
STEP 1: Identify all Classes

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(OO Design)
STEP 1: Identify all Classes

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OO Analysis and Design (OO Design)
STEP 1: Identify all Classes

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OO Analysis and Design
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STEP 1: Identify all Classes

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OO Analysis and Design
(OO Design)
STEP 1: Identify all Classes

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- Then, each OO Design Analyst is assigned one or more cards and then plays the role of the cards

OO Analysis and Design (OO Design)

STEP 1: Identify all Classes

- The team examines the set of use cases one by one, simulates the interaction and flow of events that are used to accomplish the use case

OO Analysis and Design
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OO Analysis and Design
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OO Analysis and Design
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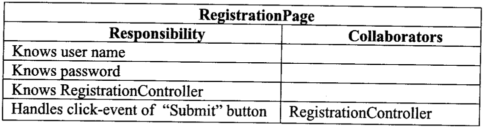
  - the session continues for all use cases and all details of each responsibility of each class are clear

OO Analysis and Design (OO Design)

STEP 1: Identify all Classes

Register: A customer visits the registration page, and specifies the desired user name and password. If there is already such a username/password pair, the system reports error; otherwise, it reports success. When the registration is completed, the user name, password, real name, and the billing address are stored in a database system.



RegistrationPage	
Responsibility	**Collaborators**
Knows user name	
Knows password	
Knows RegistrationController	
Handles click-event of "Submit" button	RegistrationController

Figure: CRC card of RegistrationPage

OO Analysis and Design
(OO Design)
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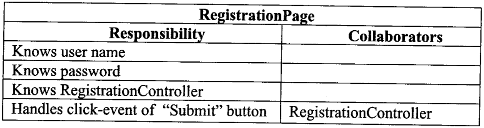

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Read Chap. 4 for the rest of the example

OO Analysis and Design (OO Design)
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- In a sequence diagram, the boxes on the top of the diagram denote objects, classes, or actors
- "successPage:RegistrationSuccessPage" $\Longrightarrow$ successPage is the object name, and RegistrationSuccessPage is the class name

OO Analysis and Design
(OO Design)
STEP 2: Construct Interaction Diagram

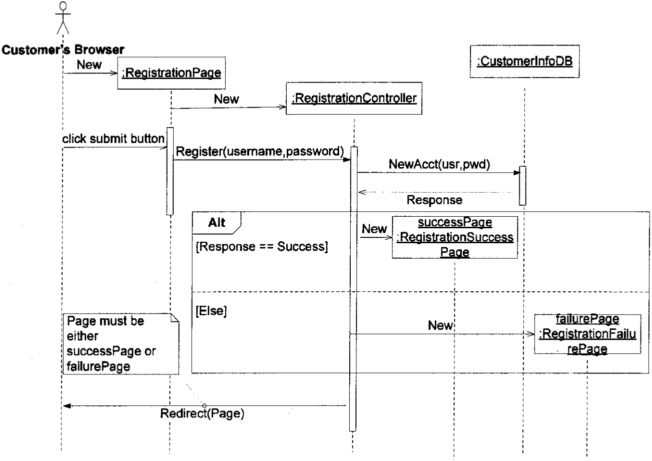

Figure: Sequence diagram for the registration use case

OO Analysis and Design

(OO Design)

STEP 3: Build State Machine Diagram

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(OO Design)
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OO Analysis and Design (OO Design)

STEP 3: Build State Machine Diagram

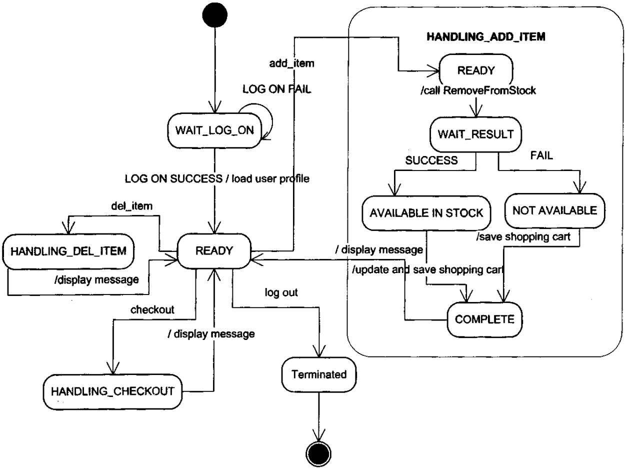

Figure: State machine diagram of SessionController class

OO Analysis and Design
(OO Design)
STEP 4: Detailed Design

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OO Analysis and Design (OO Design)
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OO Analysis and Design
(OO Design)
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OO Analysis and Design
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OO Analysis and Design
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STEP 4: Detailed Design

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OO Analysis and Design
(OO Design)
STEP 4: Detailed Design

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    - (see your notes from SFWR ENG 2A04)
- From the DD, the implementation in code should be straightforward

OO Analysis and Design (OO Design)

STEP 4: Detailed Design

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OO Analysis and Design
(OO Design)
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OO Analysis and Design
(OO Design)
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OO Analysis and Design
(OO Design)
STEP 4: Detailed Design

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OO Analysis and Design
(OO Design)
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OO Analysis and Design (OO Design) STEP 4: Detailed Design

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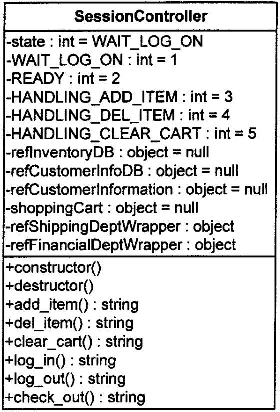
  - mutator (changes the state of the object)

OO Analysis and Design
(OO Design)
STEP 4: Detailed Design



SessionController

```
-state : int = WAIT_LOG_ON
-WAIT_LOG_ON : int = 1
-READY : int = 2
-HANDLING_ADD_ITEM : int = 3
-HANDLING_DEL_ITEM : int = 4
-HANDLING_CLEAR_CART : int = 5
-refInventoryDB : object = null
-refCustomerInfoDB : object = null
-refCustomerInformation : object = null
-shoppingCart : object = null
-refShippingDeptWrapper : object
-refFinancialDeptWrapper : object
```

```
+constructor()
+destructor()
+add_item() : string
+del_item() : string
+clear_cart() : string
+log_in() : string
+log_out() : string
+check_out() : string
```

Figure: Detailed design of Session Controller class