SOFTWARE ENGINEERING

Week 8
Software Design Engineering I

Agenda

1. Unified Modeling Language
2. Software Design Concepts
3. Structured Design
4. Object Oriented Design Principles
5. User Interface Design
6. Case Study: SafeHome

Unified Modeling Language

8.1

What is UML?

- Unified Modeling Language (UML) is the standard tool for visualizing, specifying, constructing, and documenting the artifacts of an object-oriented software.
- UML is not a programming language, but only a visual design notation.
- Can be used with all software development process models.
- Independent of implementation language.
- Many CASE tools uses UML for automatic code generation. Examples: IBM Rational, ArgoUML, etc.
- You may be familiar with some UML concepts introduced in Object Oriented Programming course.

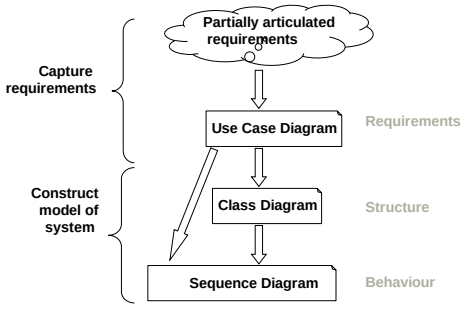
Background

- UML is the result of an effort to simplify and consolidate the large number of **Object Oriented** development methods and notations.
- Developed by the Object Management Group based on work from:
  - Grady Booch [91]
  - James Rumbaugh [91]
  - Ivar Jacobson [92]
- The latest version is UML 2.0
  (See http://www.omg.org or http://www.uml.org)

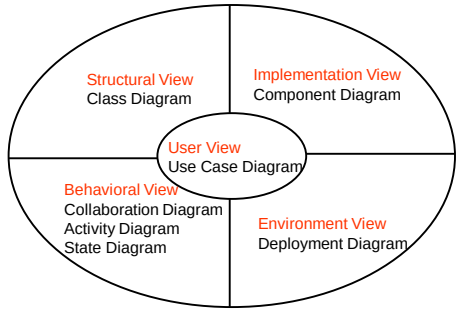
Types of UML Diagrams

- **Use Case Diagrams (*)**
- **Class Diagrams (*)**
- Interaction Diagrams
  - **Sequence Diagrams (*)**
  - Collaboration Diagrams
- State Transition Diagrams
- Activity Diagrams
- Implementation Diagrams
  - Component Diagrams
  - Deployment Diagrams

Minimal UML Process



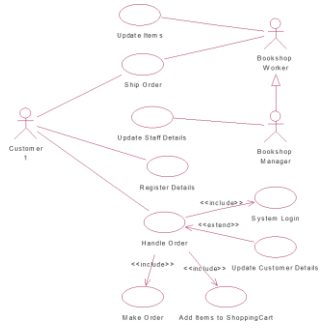
Views of UML Diagrams



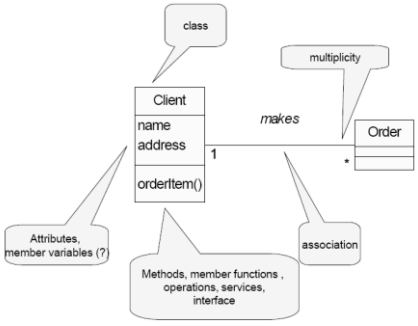
Use Cases

- Use case diagrams are used to visualize, specify, construct, and document the (intended) behavior of the system, during requirements capture and analysis.
- Provide a way for developers, domain experts and end-users to Communicate.
- Serve as basis for testing.
- Main authors: *Booch, Rumbaugh, and Jacobson*
- The Object Management Group (OMG) is responsible for standardization. (www.omg.org)
- Current version is UML 2.0

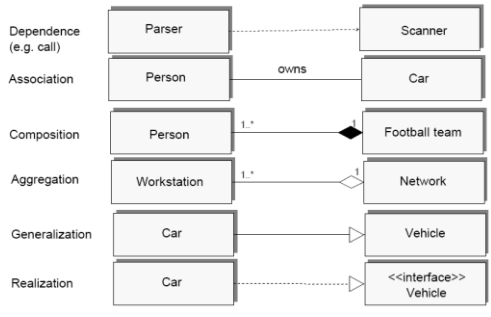
Example : Use Case Diagram



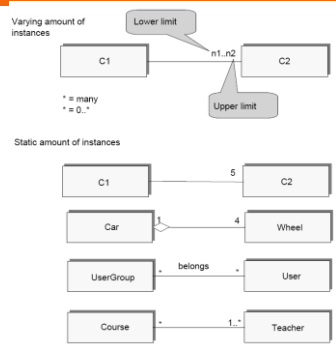
Class Diagrams



Class Relations

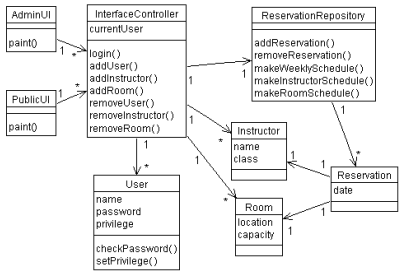


Cardinality

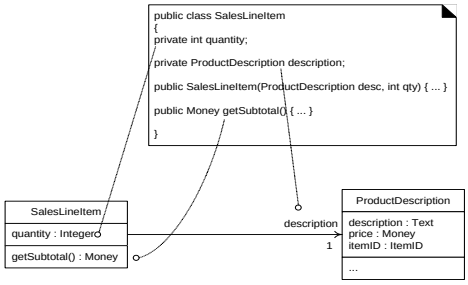


Example : Class Diagram

A classroom scheduling system: specification perspective.



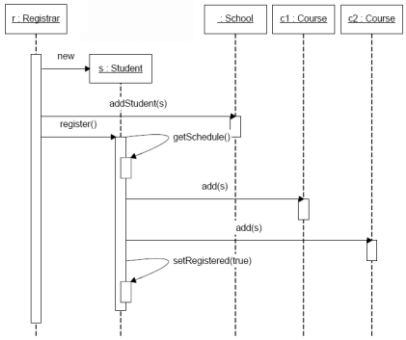
Example : From Class Diagram to Code



Interaction Diagrams

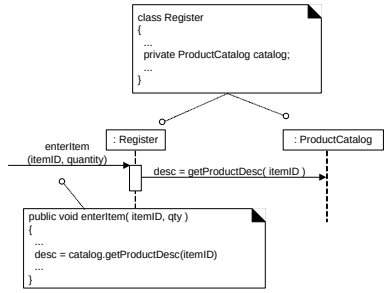
- UML presents two types of interaction diagrams.
  1. Sequence Diagrams
  2. Collaboration Diagrams

Sequence Digrams

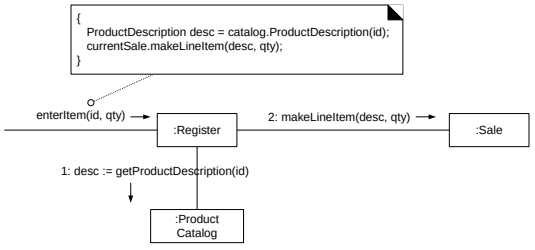


Example : Mapping Diagram to Code

- Mapping sequence diagram to Java code

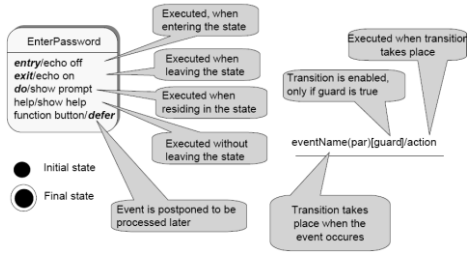


Collaboration Diagrams

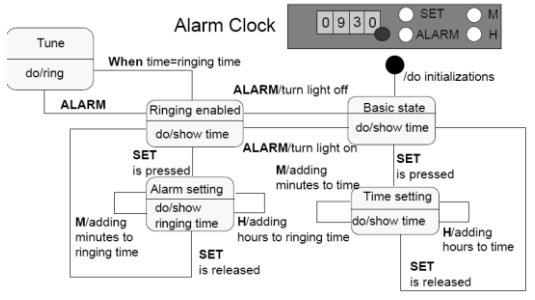


State Chart Notation

- State transition diagram shows
  - The events that cause a transition from one state to another
  - The actions that result from a state change

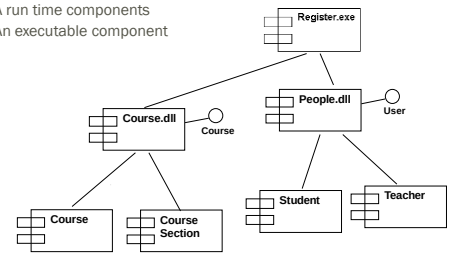


Example : State Chart Diagram



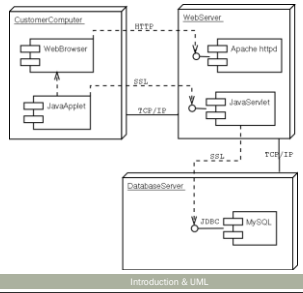
Package Diagrams

- Component diagrams illustrate the organizations and dependencies among software components in physical world.
- A component may be
  - A source code component
  - A run time components
  - An executable component

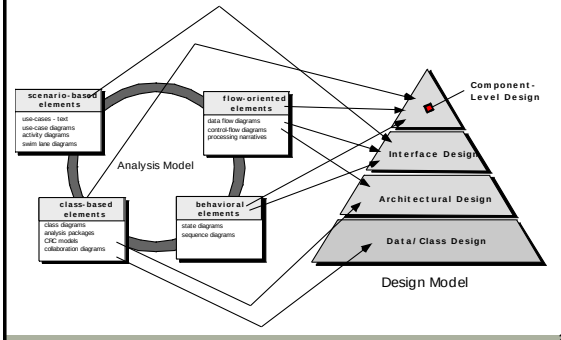


Deployment Diagrams

- Captures the distinct number of computers involved
- Shows the communication modes employed
- Component diagrams can be embedded into deployment diagrams effectively



Analysis Model ⟶ Design Model



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Software Design Concepts

8.2

Design Concepts (1)

- **Component:**
  - Any piece of software or hardware that has a clear role.
  - A component can be isolated, allowing you to replace it with a different component that has equivalent functionality.
  - Many components are designed to be reusable.
  - Conversely, others perform special-purpose functions.
- **Module:**
  - A component that is defined at the programming language level.
  - For example, functions are modules in C.
  - For example, methods, classes and packages are modules in Java.

Design Concepts (2)

- **Modularity:**
  - A complex system may be divided into simpler pieces called *modules*.
  - A system that is composed of modules is called *modular*.
  - When dealing with a module we can ignore details of other modules.
  - Use divide and conquer method for modularity.
  - For two modules m1 and m2, the effort relation is as follows:

$$E(m1) + E(m2) < E(m1+m2)$$

Design Concepts (3)

- **Abstraction:**
  - Abstraction is a means of achieving stepwise refinement by suppressing unnecessary details.
  - It is to conceptualize problem at a higher level.
  - Abstractions allow you to understand and concentrate on the essence of a subsystem without having to know unnecessary details.
  - The designer should keep the level of abstraction as high as possible.
- **Data abstraction (Abstract Data Type):**
  - A data type together with the operations performed on instantiations of that data type.
- **Procedural abstraction:**
  - The designer defines a procedure at a higher level.

Example: C definition without Data Abstraction

```
struct personel
{
  long int TCNum;
  char Ad[20], Soyad[20];
  int DTarihi_gun, DTarihi_ay, DTarihi_yil;
  int IGTarihi_gun, IGTarihi_ay, IGTarihi_yil;
} ;
```


Example: C definition with Data Abstraction

```
typedef struct
{
  int gun, ay, yil;
} tarih;

struct personel
{
  long int TCNum;
  char Ad[20], Soyad[20];
  tarih DogumTarihi;     //abstraction
  tarih IseGirisTarihi; //abstraction
} ;
```

Example:C program without Procedural Abstraction

```
#include <stdio.h>
#include <stdlib.h>
#define N 5
int main()
{
  int a[N] = {10,20,30,40,50};
  int b[N] = {15,25,35,45,55};
  int i;
  for (i=0; i < N; i++)  printf("%d \t", a[i]);
  printf("\n");
  for (i=0; i < N; i++)  printf("%d \t", b[i]);
  return 0;
}
```

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Example:C program with Procedural Abstraction

```
#include <stdio.h>
#include <stdlib.h>
#define N 5

void yaz(int dizi[], int M) {
  int i;
  for (i=0; i < M; i++)
    printf("%d \t", dizi[i]);
  printf("\n");
}
int main() {
  int a[N] = {10,20,30,40,50};
  int b[N] = {15,25,35,45,55};
  yaz(a, N); //abstraction
  yaz(b, N); //abstraction
  return 0;
}
```

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Layers of Software Design

1. Architectural Design
2. Modular Design
   1. Data Design
      - Transforms the information domain model created during the analysis into the data structures, file structures, database structures that will be required to implement software.
      - Data objects and relationships in ERD and the detailed data content depicted in the data dictionary provide the basis.
   2. Behavioral Design
      - Transforms structural elements of the program architecture into a procedural description of software components.
      - Information obtained from PDL (Algorithms / Flowcharts) serve as basis.
3. User Interface Design

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Structured Design Approach

8.3

Data-Oriented Design

- Basic principle
  - The structure of a product must conform to the structure of its data
- Three very similar methods
  - Michael Jackson [1975], Warnier [1976], Orr [1981]
- Data-oriented design
  - Has never been as popular as action-oriented design
  - With the rise of OOD, data-oriented design has largely fallen out of fashion

Operation-Oriented Design

- Data flow analysis
  - Use it with most specification methods (Structured Systems Analysis here)
- Key point: We have detailed action information from the DFD

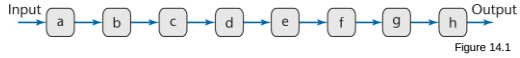

Figure 14.1

Data Flow Analysis

- Every product transforms input into output
- Determine
  - "Point of highest abstraction of input"
  - "Point of highest abstract of output"

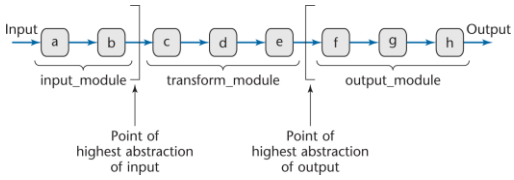

Figure 14.2

Data Flow Analysis (contd)

- Decompose the product into three modules
- Repeat stepwise until each module has high cohesion
  - Minor modifications may be needed to lower the coupling

Mini Case Study: Word Counting

- Example:

  Design a product which takes as input a file name, and returns the number of words in that file (like UNIX *wc*)

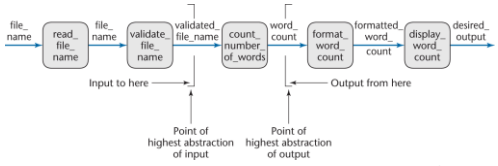

Figure 14.3

Mini Case Study: Word Counting

- First refinement

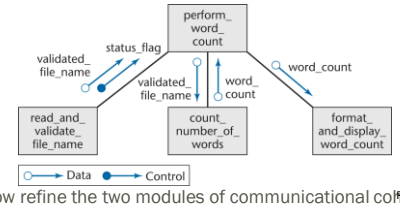

Figure 14.4

- Now refine the two modules of communicational cohesion

Mini Case Study: Word Counting

- Second refinement

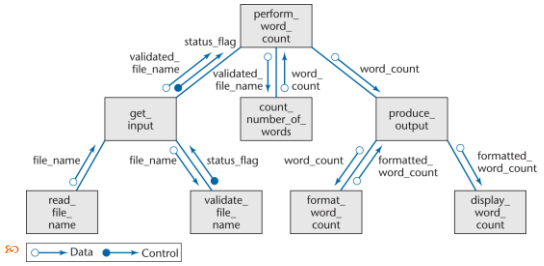

Figure 14.5

Word Counting: Detailed Design

- The architectural design is complete
  - So proceed to the detailed design
- Two formats for representing the detailed design:
  - Tabular
  - Pseudocode (PDL — program design language)

Detailed Design: Tabular Format

Module name	**count_number_of_words**
Module type	Function
Return type	**integer**
Input arguments	**validated_file_name : string**
Output arguments	None
Error messages	None
Files accessed	None
Files changed	None
Modules called	None
Narrative	This module determines whether **validated_file_name** is a text file, that is, divided into lines of characters. If so, the module returns the number of words in the text file; otherwise, the module returns **−1**.

Figure 14.6(c)

Detailed Design: PDL Format

```
void perform_word_count ( )
{
  String                validated_file_name;
  int                   word_count;

  if (get_input (validated_file_name) is null)
    print "error 1: file does not exist";
  else
  {
    set word_count equal to count_number_of_words (validated_file_name);
    if (word_count is equal to −1)
      print "error 2: file is not a text file";
    else
      produce_output (word_count);
  }
}

String get_input ( )
{
    String                file_name;

    file_name = read_file_name ( );
    if (validate_file_name (file_name) is true)
    {
      return file_name;
    }
    else
      return null;
}

void display_word_count (String formatted_word_count)
{
    print formatted_word_count, left justified;
}

String format_word_count (int word_count);
{
    return "File contains" word_count "words";
}
```

Figure 14.7

Data Flow Analysis Extensions

- In real-world products, there is
  - More than one input stream, and
  - More than one output stream

Data Flow Analysis Extensions

- Find the point of highest abstraction for each stream

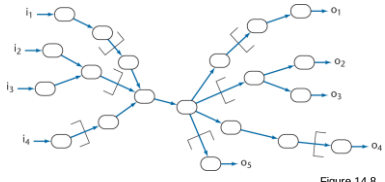

Figure 14.8

- Continue until each module Works on a single responsibility