Structured programming in software project

@2016-2017

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Covered topics

- Overview
- Structure of a program
- Separation of concerns

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Objectives

- After this lesson, students will be able to:
  - Recall the term of structured programming
  - Summarize the relationships between software qualities, algorithms and the structure of program.
  - Formulate the separation of concerns.

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I. OVERVIEWS

1. Introduction
2. Concepts of structured programming
3. Advantages
4. Disadvantages

7

7

1. Introduction

- Software engineering = problem solving activities
  - Understanding the problem
  - Designing an algorithm as a solution
  - Implementing the algorithm in a computer program
- Algorithm: sequence of steps that take from the input to the output for solving a problem
  - Correct: provide a correct solution according to the specifications
  - Finite : terminate
  - General: work for every instance of a problem
  - Efficient : use few resources (time, memory, bandwith, etc.)

→ **Need of a structured approach**

8

8

2.1. What is structured programming?

- Initially: programming without the use of the GOTO statement
- Then: a method of writing a computer program to minimize the problem complexity:
  - top-down analysis for problem solving
  - modularization for program structure and organization
  - structured code for the individual modules

9

9

2.1. What is structured programming?

- Now: a method of designing software components / program elements and their relationships to:
  - Minimize complexity
  - Adapt to change (identify modifications for additional functionalities or correcting errors)
  - Improve the reliability and clarity of programs

10

10

2.2. Structured programming: structured design of software

- Conceptualizing a problem into several well-organized elements of solution (mostly based on "divide and conquer" strategy)
- Maintaining the unified structure at different levels
  - Problem solving: top-down, bottom-up, middle-out
  - Program abstraction and organization: modules, services, functions, objects, …
  - Program elements: structured code

11

11

3. Advantages of structured programming

- The sequence of operations is simple to trace, thus facilitating debugging.
- There are a finite number of structures with standardized terminology.
  - Structures lend themselves easily to building subroutines.
  - The set of structures is complete; that is, a programs can be written using these structures.
- Structures are self-documenting and, therefore, easy to read.
- Structures are easy to describe in flowcharts, syntax diagrams, pseudo code, and so on.
- Structured programming results in increased programmer productivity-programs can be written faster.

12

12

4. Disadvantages of structured programming

- Some high-level languages (Pascal, C, Java, Lisp, …) accept the structures directly; while others require an extra stage of translation.
- In some cases, structured programs may execute slower and require more memory than the unstructured equivalent.
- Some problems (a minority) are more difficult to solve using only the three structures rather than a brute-force "spaghetti" approach.
- Nested structures can be difficult to follow.

13/49

13

II. STRUCTURE OF PROGRAMS

1. Structure of computer programs
2. Control structures
3. Data structures
4. Functions and procedures as program elements

14

14

- How is the structure of a computer program represented ?
- Given a set of programming languages and programs that are written by using these languages. How do these programs differ from ?

15

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1. Structure of computer programs

Program

- Library, package
  - File, class
    - Function, procedure, method
      - Block
        - » Statement
          - Expression
            - Word, token

Book

- Part
  - Chapter
    - Section
      - Paragraph
        - » Sentence
          - Phrase
            - Word

16

2. Control structures

- Computer program represents an algorithm resolving a given problem.
- All computer programs, no matter how simple or how complex, are written using one or more of three basic structures:
  - Sequence
  - Selection
  - Repetition
- These structures are called control structures or logic structures, because they control the program logic

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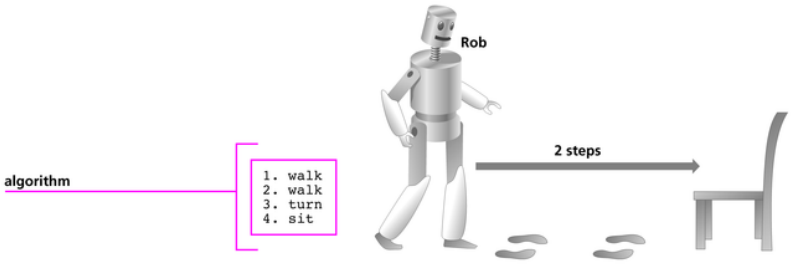
2.1. Sequence structure

- The sequence structure in a computer program directs the computer to process the statements one after another, in the order listed in the program



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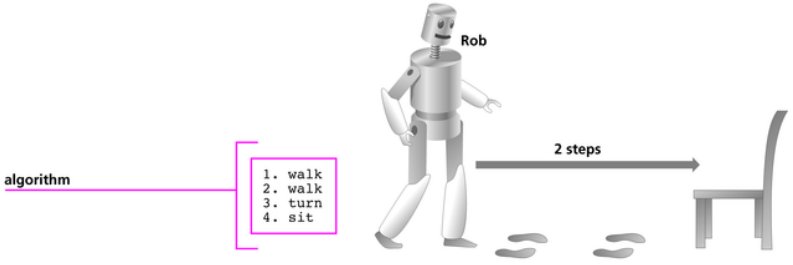
2.1. Sequence structure

- A statement may be:
  - Assignment statement
  - Input /output statement
  - Composite statement



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2.2. Selection structure

- Make a decision, and then take an appropriate action based on that decision
- Provide the appropriate action to take based on the result of that decision
- The decision depends on various condition values

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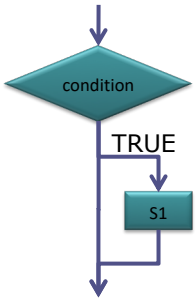
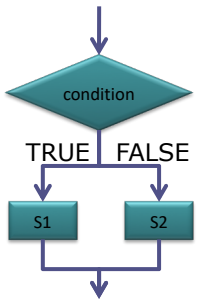
2.2. Selection structure

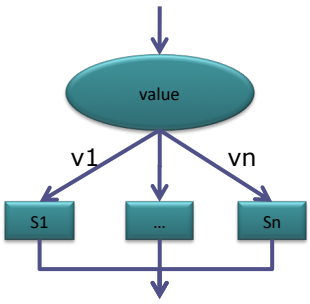
Single input – single output



Single input – double output



Single input – multiple output



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2.2. Selection structure


```
1.  repeat 20 times:
        walk
2.  if the balloon is red, do this:
        drop the balloon in the red box
    otherwise, do this:
        drop the balloon in the yellow box
3.  turn
4.  repeat 20 times:
        walk
5.  turn
```

algorithm

indent the instructions within the `if` and `otherwise` sections of a selection structure

22

22

2.3. Repetition structure

- Allow the programmer to specify that an action should be repeated, depending on the condition value
- When used in a program, the repetition structure, also referred to as a loop, directs the computer to repeat one or more statements until some condition is met, at which time the computer should stop repeating the statements

23

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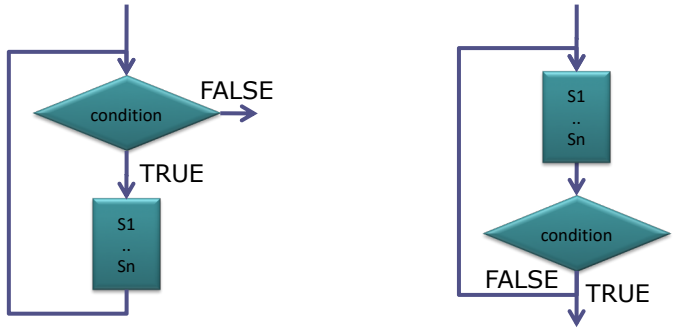
2.3. Repetition structure



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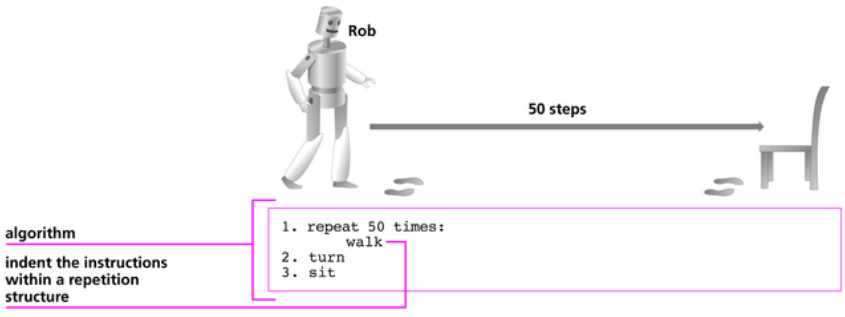
2.3. Repetition structure

- Case 1: The repetition number is known in advance



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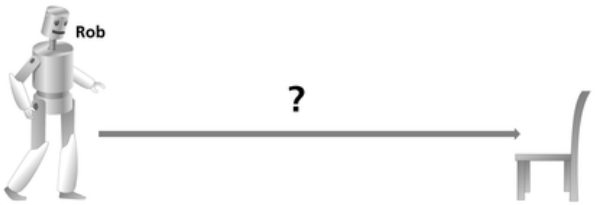
2.3. Repetition structure

- Case 2: The repetition number is not known in advance
- Statements in the body of this repetition structure are executed repeatedly as long as the loop-continuation test is evaluated to false
  - The condition is first evaluated: may be none of these statements is executed
  - Otherwise, these statements are executed at least one time



algorithm

```
1. repeat until you are directly in front of the chair:
       walk
2. turn
3. sit
```

26

26

3. Data structures

- How to choose or devise the appropriate data structures for a problem ?
  - Algorithms will have to manipulate data in some way → The way we choose to store and organize our data (i.e. data structure) directly affects the efficiency of our algorithm
  - Classic data structures : design, implementation and use

27

27

Type

- Primitive type:
  - Integer, Boolean, String, …
- Composite type
  - Tuple
- Abstract data type: data structure that is defined indirectly by the operations that may be performed on it, and the mathematical properties of those operations
  - Array
  - List
  - Tree
  - Hash
  - Graph

28

28

4. Functions and procedures as program elements

- Functions and procedures are part of computer program. They can be custom-defined.
- A function or a procedure is built out of control structures in order to manipulate on the determined data structures.
- Functions are really mathematical relations that map every input to exactly one output. Functions are designed to return their output value.
- Procedures are recipes for computation that perform side effects.
- Either function or procedure **is used to represent a concern.**

29

29

Example: Functions and procedures

- C, C++, Java : no distinct
- Pascal, .NET:
  - function returns value
  - procedure doesn't return value.
- DBMS:
  - procedures (SPROCs) : stored compiled queries
  - functions (UDFs): built-in piece of expressions used to build queries

30

30

III. SEPARATION OF CONCERNS

1. Principles
2. Concerns
3. Types of separation
4. Stakeholders of concerns

31

31

1. Principles

- The principle of separation of concerns states that software should be organized so that each program element does one thing and one thing only.
- Each program element should therefore be understandable without reference to other elements.
- Program abstractions (procedures, objects, etc.) support the separation of concerns.
  - Procedural programming languages such as C and Pascal can separate concerns into procedures.
  - Object-oriented programming languages such as Java can separate concerns into objects.
  - Service-oriented architecture can separate concerns into services.

32

2. Concerns

- A concern is an area of interest or focus in a system.
- Concerns are the primary criteria for decomposing software into smaller, more manageable and comprehensible parts that have meaning to a software engineer.
  - Procedural programming, describing concerns as procedures
  - Object-oriented programming, describing concerns as objects

33

3. Types of separation

- Quality: deal separately different quality aspects of the system
  - E.g.: security
- Time: plan the activity of a system
  - E.g.: software life cycle
- View: consider & analyze separately the system
  - E.g.: control flow, data flow
- Size: dominate the system complexity
  - E.g.: component

34

34

4. Stakeholder concerns

- Functional concerns: related to specific functionalities to be included in a system
- Quality of service concerns: related to the non-functional behaviors of a system
- Policy concerns: related to the overall policies that govern the use of the system
- System concerns: related to attributes of the system as a whole, such as its maintainability or its configurability
- Organizational concerns: related to organizational goals and priorities such as:
  - producing a system within budget
  - making use of existing software assets
  - maintaining the reputation of an organization

35

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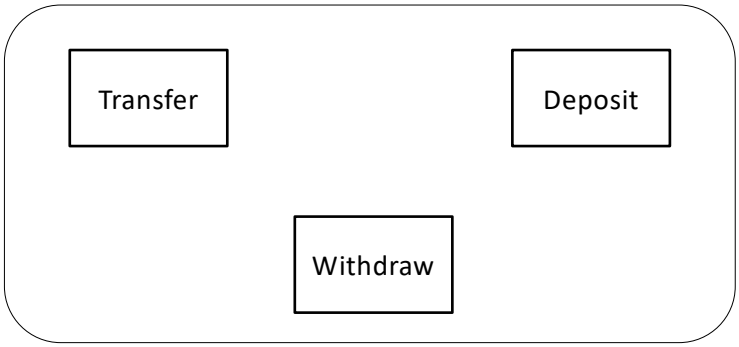
5. Example: Banking system

- Concerns are not program issues but reflect the system requirements and the priorities of the system stakeholders.
- By reflecting the separation of concerns in a program, there is clear mapping from requirements to implementation.



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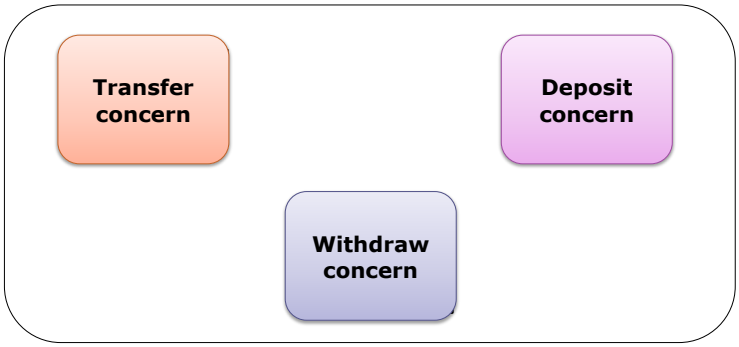
Example: Banking system's core concerns

- Core concerns: functional concerns relating to the primary purpose of a system



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Example: Transfer concern

- Core concern allows bank customers to transfer an amount of money from a given account to another account

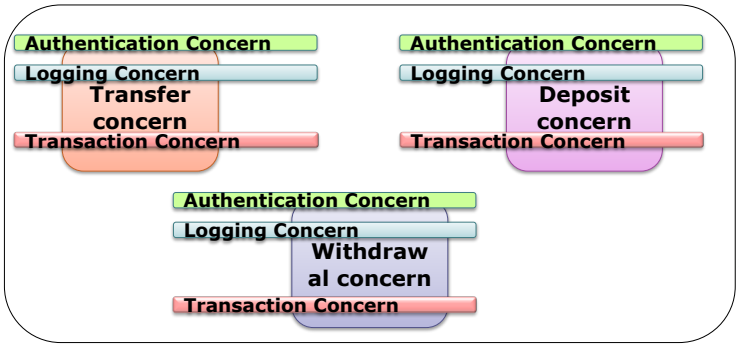
```
void transfer(Account fromAccount, Account toAccount, int amount) {
        if (fromAccount.getBalance() < amount) {
                throw new InsufficientFundsException();
        }
        fromAccount.withdraw(amount);
        toAccount.deposit(amount);
}
```

38

38

Example: Banking system's secondary concerns

- Secondary concerns: functional concerns that reflect non-functional and QoS requirements



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Example: authentication, transaction and logging concerns

```
void transfer(Account fromAccount, Account toAccount, int amount) throws Exception {
    if (!getCurrentUser().canPerform(OP_TRANSFER)) {
        throw new SecurityException();
    }
    Transaction tx = database.newTransaction();
    try {
        if (fromAccount.getBalance() < amount) {
            throw new InsufficientFundsException();
        }
        fromAccount.withdraw(amount);
        toAccount.deposit(amount);
        tx.commit();
        systemLog.logOperation(OP_TRANSFER, fromAccount, toAccount, amount);
    }
    catch(Exception e){
        tx.rollback();
        throw e;
    }
}
```

Authentication Concern

Transaction Concern

Transfer Concern

Transaction Concern

Logging Concern

Transaction Concern

40

Quiz and Exercises

- Now let's go over what you have learned through this lesson by taking a quiz.
- When you're ready, press Start button to take the quiz

41

41

1. Which of the following statements are true ? Why ?

A. Sequence, selection and repetition are three control structures dedicated for modeling the relationships between program elements.

B. Data structures are abstracted by means of operations that can be performed on a domain of values.

C. Functions and procedures are the operations' representation, depending on different contexts of use: programming languages, technologies, etc.

D. Separation of concerns isolates the issues to concentrate on one at a time.

E. Separation of concerns does not support parallelization of efforts and separation of responsibilities

42

42

2. Discussion

- What is a well structured program ?

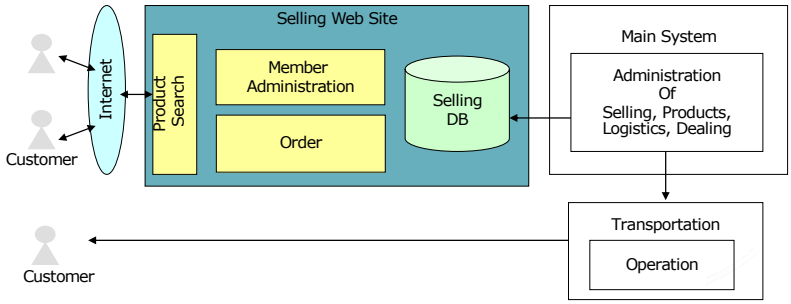
- How to write a well structured program ?

43

43

3. Exercises

- The XYZ Wear Corporation plans to develop (from system analysis to operation testing) the web site for selling wears through Internet and to form the new whole system as follow:



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3. Exercises

- Please help users in clarification of the website's core functionalities (> = 5) .
- Create the image of software quality by nominating the assessment criteria of website (common qualities, process qualities, application - specific qualities).
- Write down the users' requirements on the following aspects of website: functional, QoS, policy, system and organizational.
- Separate the concerns accordingly to the following criteria: quality, time, view and size.

45

45

Expected results

- Document (2-5 A4 pages) with table of contents, diagram/figure, references
  - What are the core functionalities?
    - 5-7 functionalities (input, action/process, output) among the identified must-have functionalities
  - Why do you think they are core functionalities?
    - External view point: how these functionalities represent the application logic of the website / the users' requirements?
    - Internal view point: how these functionalities compose your code ? How they represent the implementation/Deployment requirements?

  → Recheck the requirements you write down in the next.

46

46

4. Exercises

- Write a well-structured program that
  - reads a set of floating point values from the user in the range [0, 100]
  - computes and prints the average,
  - finds and prints the maximum value,
  - finds and prints the minimum value,
  - prints the values in sorted order
- Using
  - Sequence, selection, and repetition structures (JSP diagram)
  - At least 2 different programming languages

47

47