MODULE -4

- Software Testing Principles
- Program Inspections
- Program Walkthroughs
- Program Reviews

INTRODUCTION

- **Software testing** is a process, or a series of processes, designed to make sure computer code does what it was designed to do and, conversely, that it does not do anything unintended.
- Software should be predictable and consistent, presenting no surprises to users.

- Even a seemingly simple program can have hundreds or thousands of possible input and output combinations.
- Creating test cases for all of these possibilities is impractical.
- Complete testing of a complex application would take too long and require too many human resources to be economically feasible.
- In addition, the software tester needs the proper attitude (perhaps “vision” is a better word) to successfully test a software application.
- In some cases, the tester’s attitude may be more important than the actual process itself.

- When you test a program, you want to add some value to it.
- Adding value through testing means raising the quality or reliability of the program.
- Raising the reliability of the program means finding and removing errors.
- Therefore, don’t test a program to show that it works; rather, start with the assumption that the program contains errors (a valid assumption for almost any program) and then test the program to find as many of the errors as possible.
- Thus, a more appropriate definition is this:

Testing is the process of executing a program with the intent of finding errors.

- Given our definition of program testing, an appropriate next step is to determine whether it is possible to test a program to find all of its errors.
- it is impractical, often impossible, to find all the errors in a program.
- To combat the challenges associated with testing economics, you should establish some strategies before beginning.
- Two of the most prevalent strategies include black-box testing and white-box testing

Black-Box Testing

- One important testing strategy is black-box testing (also known as datadriven or input/output-driven testing).
- Your goal is to be completely unconcerned about the internal behavior and structure of the program. Instead, concentrate on finding circumstances in which the program does not behave according to its specifications.
- In this approach, test data are derived solely from the specifications (i.e., without taking advantage of knowledge of the internal structure of the program).

- If you want to use this approach to find all errors in the program, the criterion is exhaustive input testing, making use of every possible input condition as a test case.
- Exhaustive input testing is impossible.
  - Two important implications of this: (1) You cannot test a program to guarantee that it is error free; and (2) a fundamental consideration in program testingis one of economics.

White-Box Testing

- Another testing strategy, white-box (or logic-driven) testing, permits you to examine the internal structure of the program.
- This strategy derives test data from an examination of the program's logic (and often, unfortunately, at the neglect of the specification).
- The analog is usually considered to be exhaustive path testing.
- Exhaustive path testing-. That is, if you execute, via test cases, all possible paths of control flow through the program, then possibly the program has been completely tested.
- Exhaustive path testing, like exhaustive input testing, appears to be impractical, if not impossible.

Software Testing Principles

TABLE 2.1 Vital Program Testing Guidelines

Principle Number	Principle
1	A necessary part of a test case is a definition of the expected output or result.
2	A programmer should avoid attempting to test his or her own program.
3	A programming organization should not test its own programs.
4	Any testing process should include a thorough inspection of the results of each test.
5	Test cases must be written for input conditions that are invalid and unexpected, as well as for those that are valid and expected.
6	Examining a program to see if it *does not do what it is supposed to do* is only half the battle; the other half is seeing whether the program *does what it is not supposed to do*.
7	Avoid throwaway test cases unless the program is truly a throwaway program.
8	Do not plan a testing effort under the tacit assumption that no errors will be found.
9	The probability of the existence of more errors in a section of a program is proportional to the number of errors already found in that section.
10	Testing is an extremely creative and intellectually challenging task.

Principle 1: A necessary part of a test case is a definition of the expected output or result.

- In spite of the proper destructive definition of testing, there is still a subconscious desire to see the correct result.
- One way of combating this is to encourage a detailed examination of all output by precisely spelling out, in advance, the expected output of the program.
- Therefore, a test case must consist of two components:
  1. A description of the input data to the program.
  2. A precise description of the correct output of the program for that set of input data.

Principle 2: A programmer should avoid attempting to test his or her own program.

- it's a bad idea to attempt to edit or proofread his or her own work.
- they really don't want to find errors in their own work
- After a programmer has constructively designed and coded a program, it is extremely difficult to suddenly change perspective to look at the program with a destructive eye.
- The program may contain errors due to the programmer's misunderstanding of the problem statement or specification.

- If this is the case, it is likely that the programmer will carry the same misunderstanding into tests of his or her own program.
- This does not mean that it is impossible for a programmer to test his or her own program. Rather, it implies that testing is more effective and successful if someone else does it.
- this argument does not apply to debugging (correcting known errors); debugging is more efficiently performed by the original programmer.

Principle 3: A programming organization should not test its own programs.

- The argument here is similar to that made in the previous principle.
- One reason for this is that it is easy to measure time and cost objectives, whereas it is extremely difficult to quantify the reliability of a program.
- Therefore, it is difficult for a programming organization to be objective in testing its own programs, because the testing process, if approached with the proper definition, may be viewed as decreasing the probability of meeting the schedule and the cost objectives.
- this does not say that it is impossible for a programming organization to find some of its errors, because organizations do accomplish this with some degree of success.
- Rather, it implies that it is more economical for testing to be performed by an objective, independent party.

Principle 4: Any testing process should include a thorough inspection of the results of each test.

- This is probably the most obvious principle, but again it is something that is often unnoticed.
- There are numerous experiments that show many subjects failed to detect certain errors, even when symptoms of those errors were clearly observable on the output listings.
- Put another way, errors that are found in later tests were often missed in the results from earlier tests.

Principle 5: Test cases must be written for input conditions that are invalid and unexpected, as well as for those that are valid and expected.

- There is a natural tendency when testing a program to concentrate on the valid and expected input conditions, to the neglect of the invalid and unexpected conditions.
- Test cases representing unexpected and invalid input conditions seem to have a higher error detection yield than do test cases for valid input conditions.

Principle 6: Examining a program to see if it does not do what it is supposed to do is only half the battle; the other half is seeing whether the program does what it is not supposed to do.

- This is a consequence to the previous principle.
- Programs must be examined for unwanted side effects.
- For instance, a payroll program that produces the correct pay checks is still an erroneous program if it also produces extra checks for non-existent employees

Principle 7: Avoid throwaway test cases unless the program is truly a throwaway program.

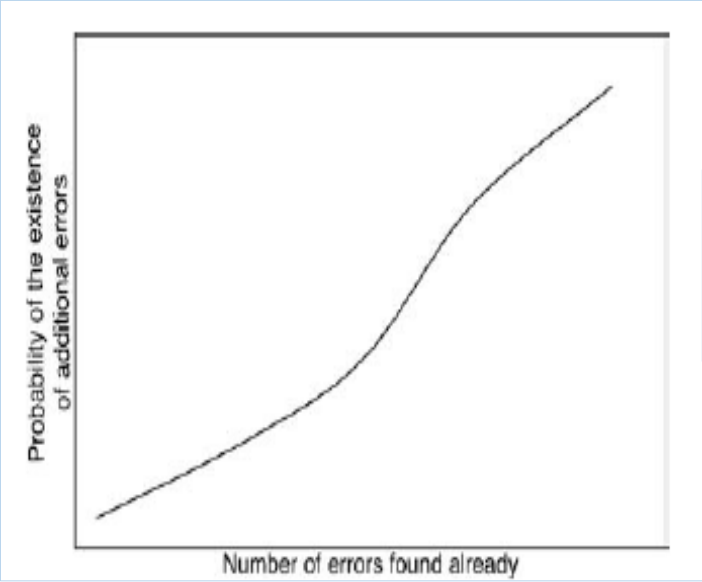
- Whenever the program has to be tested again (e.g., after correcting an error or making an improvement), the test cases must be reinvented.
- since this reinvention requires a considerable amount of work, people tend to avoid it.
- The retest of the program is rarely as rigorous as the original test, meaning that if the modification causes a previously functional part of the program to fail, this error often goes undetected.
- Saving test cases and running them again after changes to other components of the program is known as regression testing.

Principle 8: Do not plan a testing effort under the tacit assumption that no errors will be found.

- This is a mistake project managers often make and is a sign of the use of the incorrect definition of testing—that is, the assumption that testing is the process of showing that the program functions correctly.
- Once again, the definition of testing is the process of executing a program with the intent of finding errors.
- It is impossible to develop a program that is completely error free.
- Even after extensive testing and error correction, it is safe to assume that errors still exist; they simply have not yet been found.

Principle 9: The probability of the existence of more errors in a section of a program is proportional to the number of errors already found in that section.

- Errors tend to come in clusters and that some sections seem to be much more prone to errors than other sections.
- nobody has supplied a good explanation of why this occurs.
- The phenomenon is useful in that it gives us insight or feedback in the testing process.



The Surprising Relationship between Errors Remaining and Errors Found.

Principle 10: Testing is an extremely creative and intellectually challenging task.

- The creativity required in testing a large program exceeds the creativity required in designing that program.

Inspections and Walkthroughs

- The three primary human testing methods are code inspections, walkthroughs and user (or usability) testing.
- Code inspections and walkthroughs are code-oriented methods.
- These methods can be used at virtually any stage of software development, after an application is deemed to be complete or as each module or unit is complete.
- The two code inspection methods have a lot in common (similarities).

Similarities are given below…

- Inspections and walkthroughs involve a team of people reading or visually inspecting a program.
- With either method, participants must conduct some preparatory work.
- The climax is a “meeting of the minds,” at a participant conference.
- The objective of the meeting is to find errors but not to find solutions to the errors—that is, to test, not debug.

- In a walkthrough, a group of developers—with three or four being an optimal number—performs the review.
- Only one of the participants is the author of the program.
- Therefore, the majority of program testing is conducted by people other than the author, which follows testing principle 2, which states that an individual is usually ineffective in testing his or her own program.
- Inspections and walkthroughs are more effective, because people other than the program's author are involved in the process.

- Another advantage of walkthroughs, resulting in lower debugging (error-correction) costs, is the fact that when an error is found it usually is located precisely in the code.
- Modifying an existing program is a process that is more error prone (in terms of errors per statement written) than writing a new program.
- Therefore, program modifications also should be subjected to these testing processes as well as regression testing techniques.

Code Inspections (Program Inspections)

- A **code inspection** is a set of procedures and error-detection techniques for group code reading.
- An **inspection team** usually consists of four people.
- The first of the four plays the role of **moderator (**quality-control engineer).
- The moderator is expected to be a competent programmer, but he or she is not the author of the program and need not be familiar with the details of the program.

- Moderator duties include:
  - Distributing materials for, and scheduling, the inspection session.
  - Leading the session.
  - Recording all errors found.
  - Ensuring that the errors are subsequently corrected.
- The second team member is the programmer.
- The remaining team members usually are the program's designer and a test specialist.
- The specialist should be well versed in software testing and familiar with the most common programming errors.

Inspection Agenda:-

- Several days in advance of the inspection session, the moderator distributes the program's listing and design specification to the other participants.
- The participants are expected to familiarize themselves with the material prior to the session.
- During the session, two activities occur:

1. The programmer narrates, statement by statement, the logic of the program. During the discourse, other participants should raise questions, which should be pursued to determine whether errors exist. In other words, the simple act of reading aloud a program to an audience seems to be a remarkably effective error-detection technique.

2. The program is analysed with respect to checklists of historically common programming errors.

- The moderator is responsible for ensuring that the discussions proceed along productive lines and that the participants focus their attention on finding errors, not correcting them.
- The programmer corrects errors after the inspection session.
- Upon the conclusion of the inspection session, the programmer is given a list of the errors uncovered.
- List of errors is also analysed, categorized, and used to refine the error checklist to improve the effectiveness of future inspections.

- The time and location of the inspection should be planned to prevent all outside interruptions.
- The optimal amount of time for the inspection session appears to be from 90 to 120 minutes.
- The session is a mentally taxing experience, thus longer sessions tend to be less productive.
- Most inspections proceed at a rate of approximately 150 program statements per hour.
- For that reason, large programs should be examined over multiple inspections.

Human Agenda

- For the inspection process to be effective, the testing group must adopt an appropriate attitude.
- The programmer must a leave his or her ego at the door and place the process in a positive and constructive light, keeping in mind that the objective of the inspection is to find errors in the program and, thus, improve the quality of the work.
- For this reason, most people recommend that the results of an inspection be a confidential matter, shared only among the participants.

The inspection process has several **beneficial side effects.**

1. The programmer usually receives valuable feedback concerning programming style, choice of algorithms, and programming techniques.
2. The inspection process is a way of identifying early the most error-prone sections of the program, helping to focus attention more directly on these sections during the computer-based testing processes.

Error Checklist for Inspections

- An important part of the inspection process is the use of a checklist to examine the program for common errors.
- The checklist is divided into various categories:- Data Reference Errors, Data Declaration Errors, Computation Errors, Comparison Errors, Control-Flow Errors, Interface Errors and Input/Output Errors.

Data Reference Errors

- Does a referenced variable have a value that is unset or uninitialized?
- This probably is the most frequent programming error, occurring in a wide variety of circumstances.
- For each reference to a data item (variable, array element, field in a structure), attempt to “prove” informally that the item has a value at that point.
- For all references through pointer or reference variables, is the referenced memory currently allocated? This is known as the “dangling reference” problem.

Data Declaration Errors

- Have all variables been explicitly declared? A failure to do so is not necessarily an error, but is, a common source of trouble.
- Where a variable is initialized in a declarative statement, is it properly initialized?
- Are there any variables with similar names (e.g., VOLT and VOLTS)?
- Is each variable assigned the correct length and data type?

Computation Errors

- Is it possible for the divisor in a division operation to be zero?
- Are there any mixed-mode computations? (An example is when working with floating-point and integer variables.)
- Are there any computations using variables having inconsistent data types?
- Are there any computations using variables having the same data type but of different lengths?
- Is an overflow or underflow expression possible during the computation of an expression? (That is, the end result may appear to have valid value, but an intermediate result might be too big or too small for the programming language's data types.)

Comparison Errors

- Are there any mixed-mode comparisons or comparisons between variables of different lengths? If so, ensure that the conversion rules are well understood.
- Are the comparison operators correct? Programmers frequently confuse relations such as, at most, at least, greater than, not less than, and less than or equal).
- Are the operands of a Boolean operator Boolean? Have comparison and Boolean operators been erroneously mixed together? (example:- If you want to determine whether i is greater than x or y, i>xIIy is incorrect. Instead, it should be (i>x)II(i>y).

Control-Flow Errors

- Will every loop eventually terminate? Devise an informal proof or argument showing that each loop will terminate.
- Will the program, module, or subroutine eventually terminate?
- Is it possible that, because of the conditions upon entry, a loop will never execute?

Interface Errors

- Does the number of arguments passed by this module to another module equal the number of parameters expected by that module?
- Does the units system of each argument passed to another module match the units system of the corresponding parameter in that module?
- If built-in functions are invoked, are the number, attributes, and order of the arguments correct?

Input / Output Errors

- Does the program properly handle “File not Found” errors?
- Are I/O error conditions handled correctly?
- Are there spelling or grammatical errors in any text that is printed or
- displayed by the program?
- Have all files been opened before use?
- Have all files been closed after use?
- Is sufficient memory available to hold the file your program will read?

Walkthroughs

- The code walkthrough, like the inspection, is a set of procedures and error-detection techniques for group code reading.
- It shares much in common with the inspection process, but the procedures are slightly different, and a different error-detection technique is employed.
- Like the inspection, the walkthrough is an uninterrupted meeting of one to two hours in duration.
- The walkthrough team consists of three to five people.

- One of these people plays a role similar to that of the moderator in the inspection process; another person plays the role of a secretary (a person who records all errors found); and a third person plays the role of a tester. Of course, the programmer is one of those people. Suggestions as to who the three to five people should be vary.
- Suggestions for the other participants include: A highly experienced programmer, A programming-language expert, A new programmer (to give a fresh, unbiased outlook), The person who will eventually maintain the program, Someone from a different project, Someone from the same programming team as the programmer.

- The initial procedure is identical to that of the inspection process.
- The participants are given the materials several days in advance, to allow them time to bone up on the program.
- the procedure in the meeting is different.
- Rather than simply reading the program or using error checklists, the participants "play computer."
- The person designated as the tester comes to the meeting armed with a small set of paper test cases—representative sets of inputs (and expected outputs) for the program or module.

- During the meeting, each test case is mentally executed; that is, the test data are “walked through” the logic of the program.
- The state of the program (i.e., the values of the variables) is monitored on paper or a whiteboard.
- the test cases must be simple in nature and few in number, because people execute programs at a rate that is many orders of magnitude slower than a machine.
- Hence, the test cases themselves do not play a critical role; rather, they serve as a vehicle for getting started and for questioning the programmer about his or her logic and assumptions.

- In most walkthroughs, more errors are found during the process of questioning the programmer than are found directly by the test cases themselves.
- As in the inspection, the attitude of the participants is critical.
- Comments should be directed toward the program rather than the programmer.
- In other words, errors are not regarded as weaknesses in the person who committed them. Rather, they are viewed as inherent to the difficulty of the program development.
- The walkthrough should have a follow-up process similar to that described for the inspection process.
- Also, the side effects observed from inspections (identification of error-prone sections and education in errors, style, and techniques) also apply to the walkthrough process.

Desk Checking

- A third human error-detection process is the older practice of desk checking.
- A desk check can be viewed as a one-person inspection or walkthrough:
- A person reads a program, checks it with respect to an error list, and/or walks test data through it.
- For most people, desk checking is relatively unproductive.
- One reason is that it is a completely undisciplined process.
- A second, and more important reason, is that it runs counter to testing principle 2 (A programmer should avoid attempting to test his or her own program).
- For this reason, desk checking is best performed by a person other than the author of the program.

Peer Ratings (Peer Reviews or Program Reviews)

- The last human review process is not associated with program testing (i.e., its objective is not to find errors).
- Peer rating is a technique of evaluating anonymous programs in terms of their overall quality, maintainability, extensibility, usability, and clarity.
- The purpose of the technique is to provide programmer self evaluation.
- A programmer is selected to serve as an administrator of the process.
- The administrator, in turn, selects approximately 6 to 20 participants (6 is the minimum to preserve anonymity).
- The participants are expected to have similar backgrounds.

- Each participant is asked to select two of his or her own programs to be reviewed.
- One program should be representative of what the participant considers to be his or her finest work; the other should be a program that the programmer considers to be poorer in quality.
- Once the programs have been collected, they are randomly distributed to the participants.
- Each participant is given four programs to review. Two of the programs are the ‘‘finest’’ programs and two are ‘‘poorer’’ programs, but the reviewer is not told which is which.
- Each participant spends 30 minutes reviewing each program and then completes an evaluation form.
- After reviewing all four programs, each participant rates the relative quality of the four programs.

- The evaluation form asks the reviewer to answer, on a scale from 1 to 10 (1 meaning definitely yes and 10 meaning definitely no), such questions as:
- Was the program easy to understand?
- Was the high-level design visible and reasonable?
- Was the low-level design visible and reasonable?
- Would it be easy for you to modify this program?
- Would you be proud to have written this program?
- The reviewer also is asked for general comments and suggested improvements.

- After the review, the participants are given the anonymous evaluation forms for their two contributed programs.
- They also are given a statistical summary showing the overall and detailed ranking of their original programs across the entire set of programs, as well as an analysis of how their ratings of other programs compared with those ratings of other reviewers of the same program.
- The purpose of the process is to allow programmers to self-assess their programming skills.