COURSE NAME

SOFTWARE ENGINEERING

CSC 3114

(UNDERGRADUATE)

CHAPTER 10

SOFTWARE TESTING

SOFTWARE TESTING

- Testing is the process of exercising a program with the specific intent of finding errors prior to delivery to the end user
- Software testability is simply how easily [a computer program] can be tested

Testing Shows

- Error
- Requirements Conformance
- Performance
- An indication of quality

WHO TESTS THE SOFTWARE?

Developer

- Understands the system but, will test "gently“ and, is driven by "delivery“
- Experiencing the software operation (known to the developer)

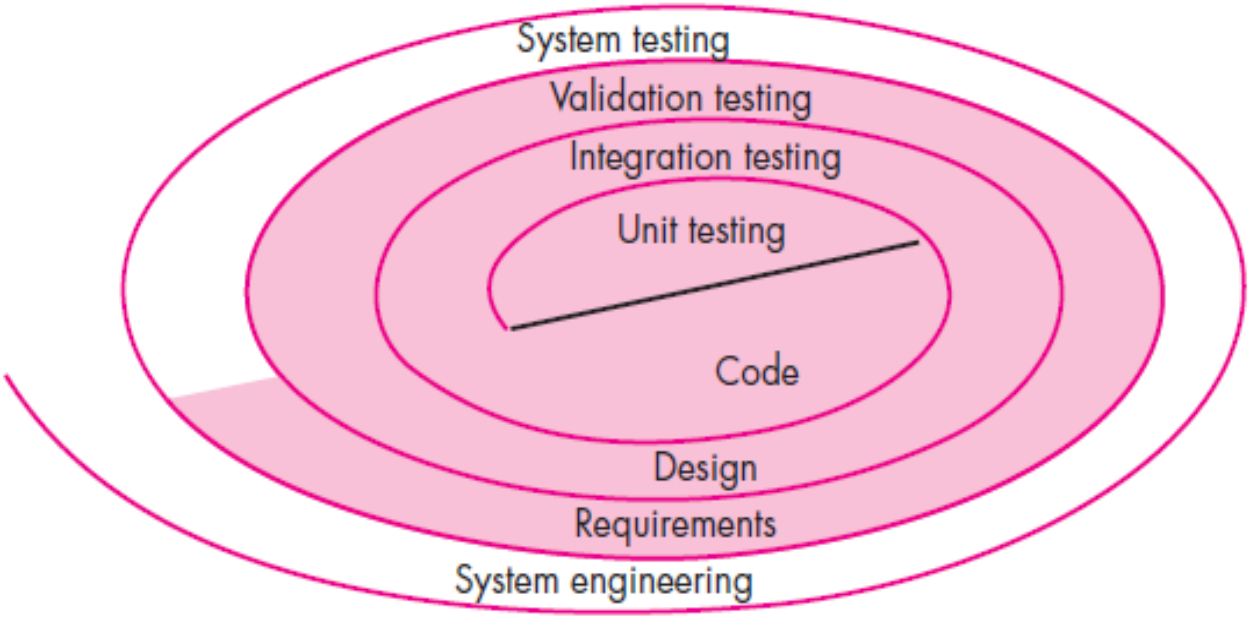
Independent tester

- Must learn about the system, but, will attempt to break it and, is driven by “quality”
- Exploring the software operation (unknown to the tester)

V & V

- *Validation* refers to a different set of tasks that ensure that the software that has been built is traceable to customer requirements.
- *Verification* refers to the set of tasks that ensure that software correctly implements a specific function/process.
- Boehm states this another way:
  - *Validation:* "Are we building the right product?“
  - *Verification:* "Are we building the product right?"

TESTING STRATEGY



TESTING STRATEGY

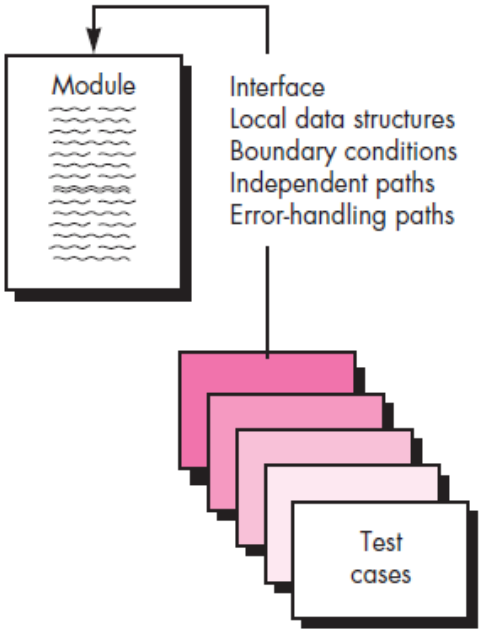
- We begin by 'testing-in-the-small' and move toward 'testing-in-the-large'
- For conventional software
  - The module (component) is our initial focus
  - Integration of modules follows
- For OO software
  - Our focus when "testing in the small" changes from an individual module (the conventional view) to an OO class that encompasses attributes and operations and implies communication and collaboration

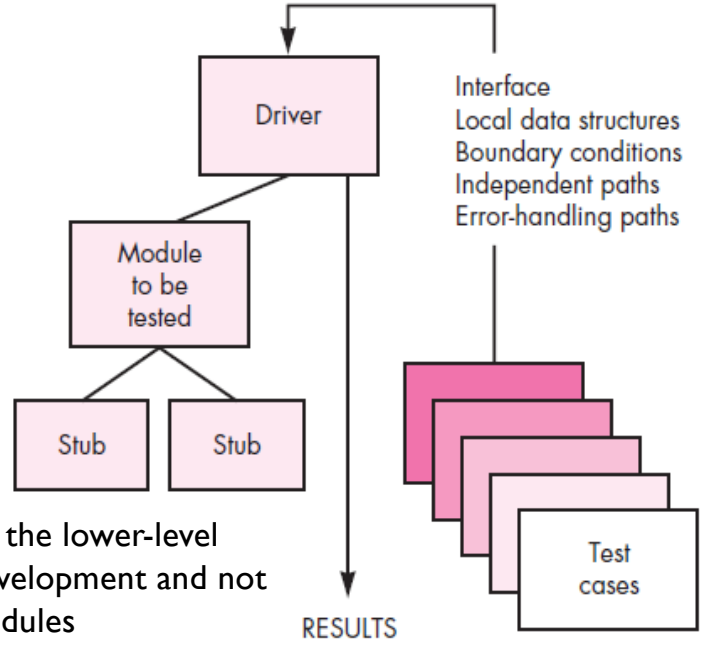
TESTING STRATEGIC ISSUES

- Specify product requirements in a quantifiable manner long before testing commences
- State testing objectives explicitly
- Understand the users of the software and develop a profile for each user category
- Develop a testing plan that emphasizes "rapid cycle testing"
- Build "robust" software that is designed to test itself
- Use effective technical reviews as a filter prior to testing; many errors will be eliminated before testing begins
- Conduct technical reviews to assess the test strategy and test cases themselves
- Develop a continuous improvement approach for the testing process

UNIT TESTING

Tests a small software unit at a time, which is typically performed by the individual programmer who implemented the unit prior to Integration testing

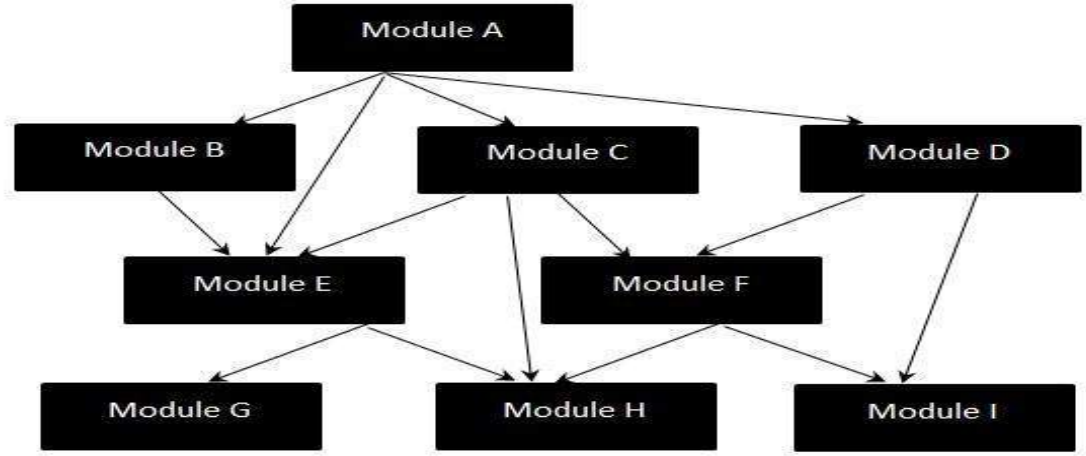




Stub: it is the behavior of the lower-level modules that are under development and not yet integrated to other modules

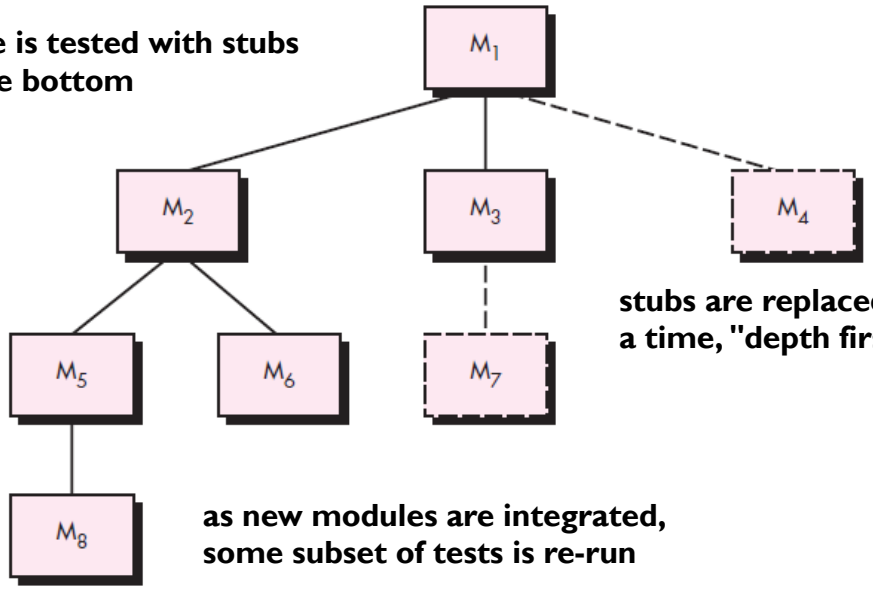
INTEGRATION TESTING STRATEGIES

- System integration testing (SIT) is a systematic technique for assembling a software system while conducting tests to uncover errors associated with interfacing the modules
- **the "big bang" approach:** Big Bang Integration Testing is an integration testing strategy where all units are linked at once, resulting in a complete system.



TOP-DOWN INTEGRATION

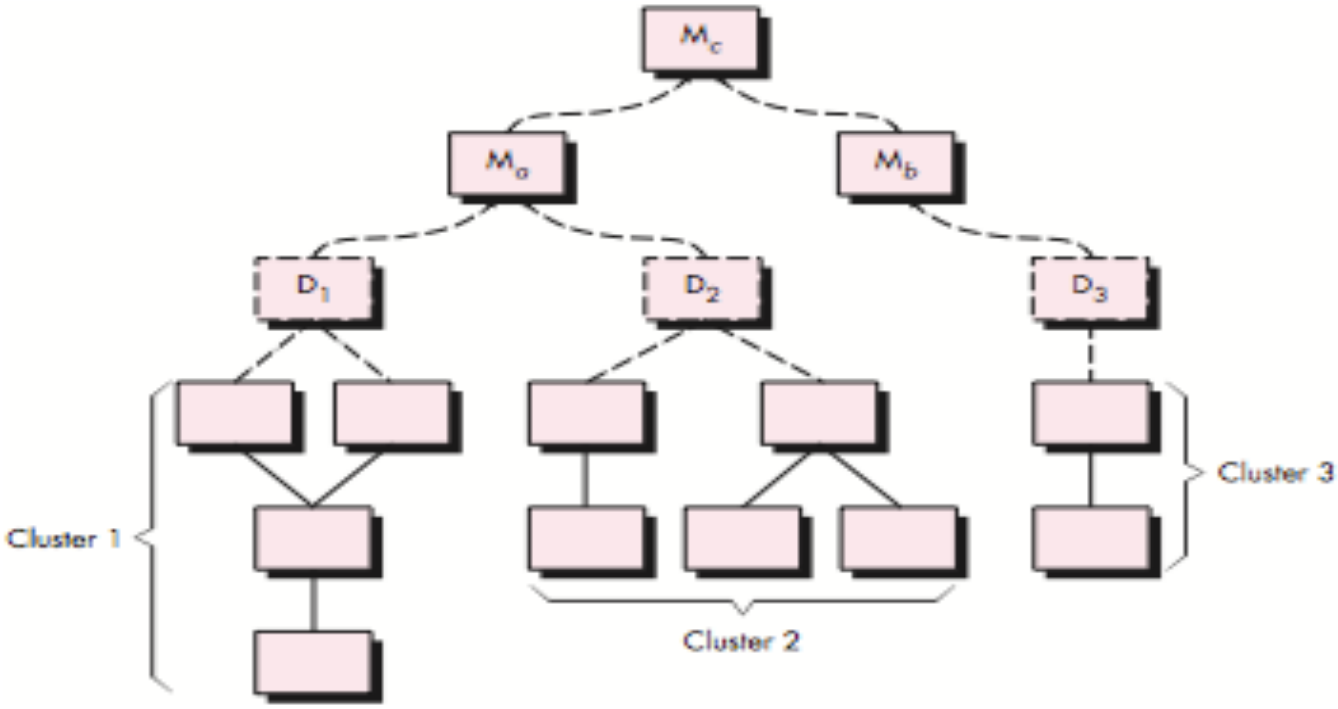
top module is tested with stubs
down to the bottom



stubs are replaced one at
a time, "depth first"

as new modules are integrated,
some subset of tests is re-run

BOTTOM-UP INTEGRATION



REGRESSION TESTING

- Regression testing is the re-execution of some subset of tests that have already been conducted to ensure that changes have not propagated unintended side effects
- Whenever software is corrected, some aspect of the software configuration (the program, its documentation, or the data that support it) is changed.
- Regression testing helps to ensure that changes (due to testing or for other reasons) do not introduce unintended behavior or additional errors.
- Regression testing may be conducted manually, by re- executing a subset of all test cases or using automated capture/playback tools.

SMOKE TESTING

Smoke testing steps:

- Software components that have been translated into code are integrated into a "**daily build**"
  - A build includes all data files, libraries, reusable modules, and engineered components that are required to implement one or more product functions.
- A series of tests is designed to expose errors that will keep the build from properly performing its function.
  - The intent should be to uncover "**show stopper**" errors that have the highest likelihood of throwing the software project behind schedule.
- The build is integrated with other builds and the entire product in its current form is smoke tested daily.
  - The integration approach may be top down or bottom up.

OBJECT-ORIENTED TESTING

- Class testing is the equivalent of unit testing
  - Operations within the class are tested
  - The state behavior of the class is examined

- Integration applied three different strategies
  - Thread-based testing—integrates the set of classes required to respond one input or event
  - Use-based testing—integrates the set of classes required to respond to one use case
  - Cluster testing—integrates the set of classes required to demonstrate one collaboration

HIGHER ORDER TESTING

- **System testing:** focus is on system integration (e.g. hardware integration, OS compatibility)
- **Alpha/Beta testing:** **Alpha testing** is simulated or actual operational **testing** by potential users or an independent **test** team at the developers' site. **Alpha testing** is often employed for off-the-shelf software as a form of internal acceptance **testing**, before the software goes to **beta testing** by users
- **Recovery testing:** forces the software to fail in a variety of ways and verifies that recovery is properly performed
- **Security testing:** verifies that protection mechanisms built into a system will, in fact, protect it from improper penetration
- **Stress testing:** executes a system in a manner that demands resources in abnormal quantity, frequency, or volume
- **Performance Testing:** test the run-time performance of software within the context of an integrated system (e.g. time required to response a request, compliance with operational constraints)

DEBUGGING

- In many cases, the non-corresponding data are a symptom of an underlying cause as yet hidden error
- The debugging process attempts to match symptom with cause, thereby leading to error correction

  - symptom may disappear when another problem is fixed
  - cause may be due to a combination of non-errors
  - cause may be due to a system or compiler error
  - cause may be due to assumptions that everyone believes

DEBUGGING TECHNIQUES

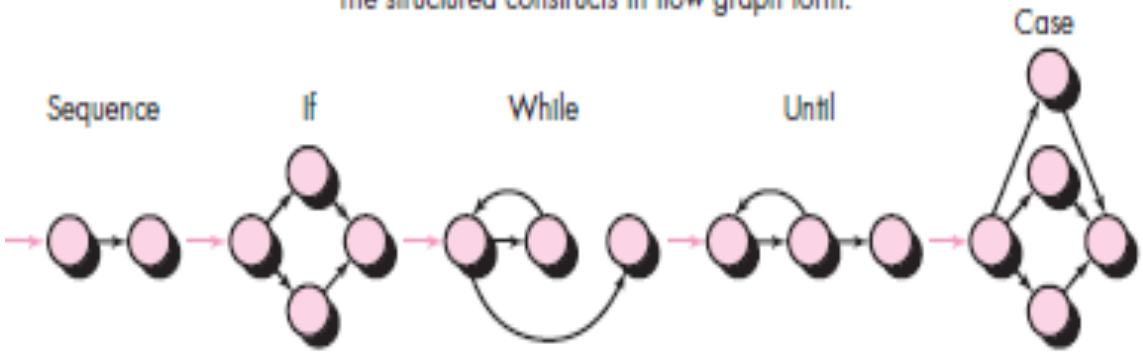
- **Brute force testing**
  - most common; but least efficient
  - memory dumps are taken, run-time traces are invoked, and the program is loaded with output statements **(Dynamic Testing)**
- **Backtracking**
  - common debugging approach that can be used successfully in small programs
  - source code is traced backward (manually) until the cause is found
- **Cause elimination**
  - a "cause hypothesis" is devised
  - if initial tests indicate that a particular cause hypothesis shows promise, data are refined in an attempt to isolate the bug (c/a-b where the possibility of a-b is zero)

BASIS-PATH TESTING

- The basis path method enables the test-case designer to derive a logical complexity measure of a procedural design and use this measure as a guide for defining a basis set of execution paths
- McCabe views a program as a directed graph in which lines of program statements are represented by nodes and the flow of control between the statements is represented by the edges

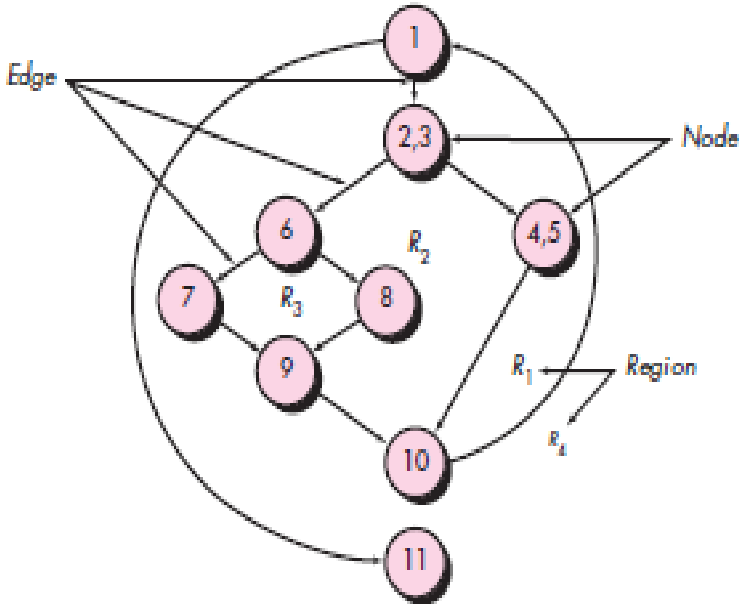
Flow Graph

The structured constructs in flow graph form:



Where each circle represents one or more nonbranching PDL or source code statements

INDEPENDENT PROGRAM PATHS



Path 1: 1-11

Path 2: 1-2-3-4-5-10-1-11

Path 3: 1-2-3-6-8-9-10-1-11

Path 4: 1-2-3-6-7-9-10-1-11

- Note that each new path introduces a new edge. The path 1-2-3-4-5-10-1-2-3-6-8-9-10-1-11 is not considered to be an independent path because it is simply a combination of already specified paths and does not traverse any new edges.
- How do you know how many paths to look for? The computation of **cyclomatic complexity** provides the answer

CYCLOMATIC COMPLEXITY

Cyclomatic complexity is a software metric that provides a quantitative measure of the logical complexity of a program. Complexity is computed in one of three ways:

1. The number of independent paths
2. The number of regions of the flow graph corresponds to the cyclomatic complexity.
   (in the previous example = 4)
3. Cyclomatic complexity $V(G)$ for a flow graph G is defined as $V(G) = E - N + 2$
   (in the previous example 11 -9 + 2 = 4)
   - where E is the number of flow graph edges and N is the number of flow graph nodes.
4. Cyclomatic complexity $V(G)$ for a flow graph G is also defined as $V(G) = P + 1$
   (in the previous example 3 + 1 = 4) [condition: 1; 2,3; 6]
   - where P is the number of predicate nodes (containing a condition) contained in the flow graph G

WHITE-BOX TESTING

Using white-box testing methods, you can derive test cases that

(1) guarantee that all independent paths within a module have been exercised at least once,

(2) exercise all logical decisions on their true and false sides,

(3) execute all loops at their boundaries and within their operational bounds, and

(4) exercise internal data structures to ensure their validity.

BLACK-BOX TESTING

- Focuses on the functional requirements of the software
- Black-box testing attempts to find errors in the following categories:

(1) incorrect or missing functions

(2) interface errors

(3) errors in external database access (accessibility)

(4) behavior or performance errors

(5) initialization and termination errors

REFERENCES

- R.S. Pressman & Associates, Inc. (2010). *Software Engineering: A Practitioner's Approach.*
- Kelly, J. C., Sherif, J. S., & Hops, J. (1992). An analysis of defect densities found during software inspections. *Journal of Systems and Software*, *17*(2), 111-117.
- Bhandari, I., Halliday, M. J., Chaar, J., Chillarege, R., Jones, K., Atkinson, J. S., & Yonezawa, M. (1994). In-process improvement through defect data interpretation. *IBM Systems Journal*, *33*(1), 182-214.