Software Systems Verification and Validation

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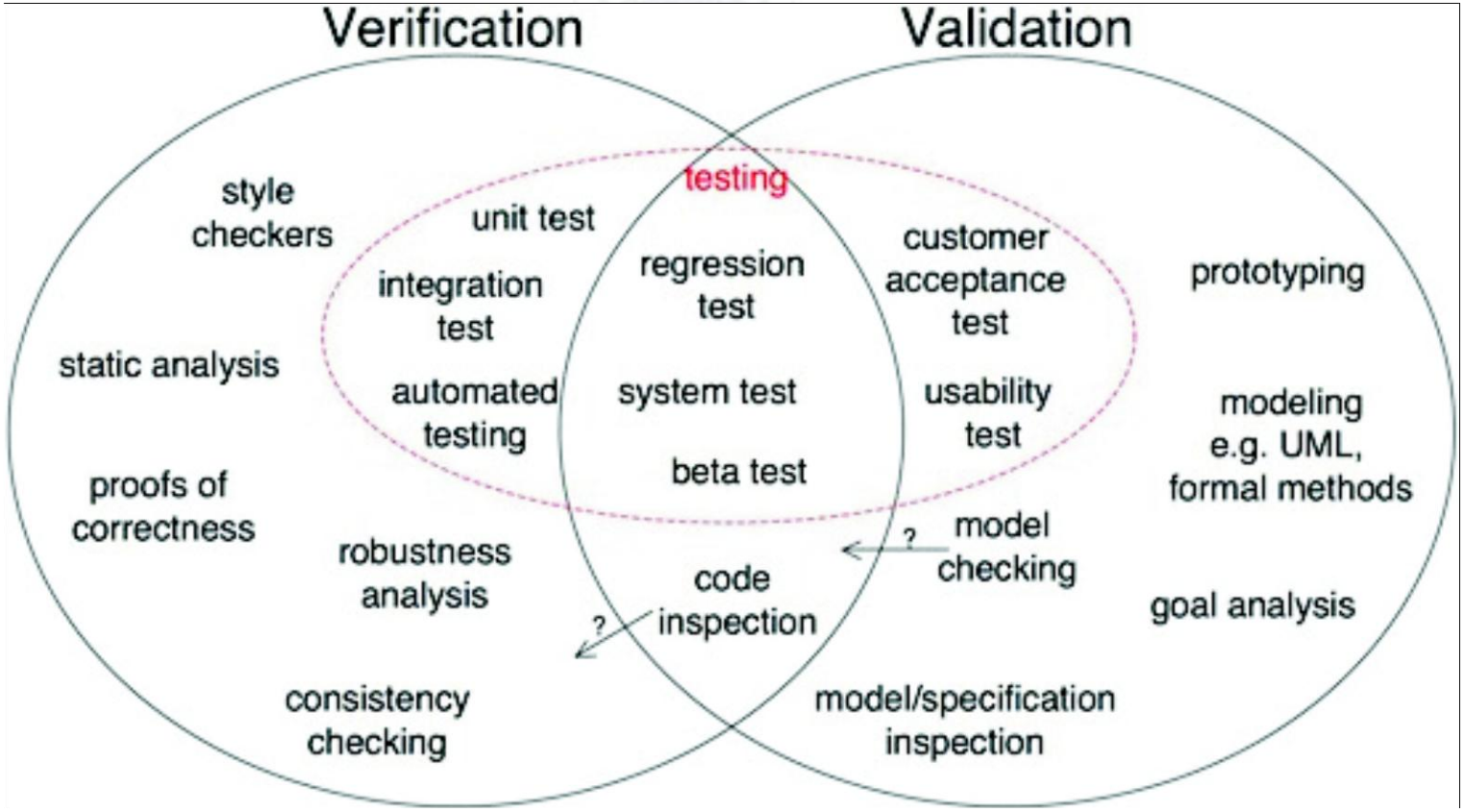
"Tell me and I forget, teach me and I may remember, involve me and I learn."

(Benjamin Franklin)

What we will learn!



(Next)/Today Lecture

- Testing. Test planning.
- Test case design - Black-box testing
- Continuous integration - Jenkins

Outline

- Testing – fundamental questions (why, how, when, enough?)
- Software testing
  - Definitions (why)
- Testing strategy (how)
- Test planning (enough)
  - Test cases
  - Testing activities
  - Bug report
- Software testing (Required reading before Seminar 2)
  - Testing principles
  - Testing axioms
- When do we test?

Testing - fundamental questions

- What skills do we need to have to test?

- Why do we test?
- How do we test?
- How do we organize the process of testing?
- When have we tested enough?
- When we test?

[Mye04] (chapter 3), [PY08] (chapter 18), [Fre10] (chapter 4)

What skills do we need to have to test?

Play … detective!

What skills do we need to have to test?

Playing detective (1)

Context 1.

A man went into a party and drank some of the punch. He then left early. Everyone at the party who drunk the punch subsequently died of poisoning. Why did the man not die?

Context 2.

A detective who was mere days from cracking an international smuggling ring has suddenly gone missing. While inspecting his last-known location, you find a note:

710 57735 34 5508 51 7718

Currently there are 3 suspects: Bill, John, and Todd. Can you break the detective's code and find the criminal's name?

Context 3.

There is a man found dead in a circular mansion. The detective interviews the cook, maid, and babysitter. The cook said he couldn't have done it because he was preparing the meal. The maid said she couldn't have done it because she was dusting the corners. The babysitter said she couldn't because she was playing with the children. Who was lying?

What skills do we need to have to test?

Playing detective (2)

Can you state (some) similarities between **a detective** and **a tester**?

Detectives	Testers

Subject of **Investigation**

Crime – commission of an act that us forbidden, harmful act against the public

Computer program (CP) – instructions for a computer, communications among humans-computers

Used **Tools**

Statements by witnesses/suspects, recording equipment, evidence kit

Test plan, management tool, screen capture tools, testing techniques, bug reports

Job **Duties**

Researching/analyzing crimes, Identifying/interrogating suspects, testifying in court

Research for information, interrogating, Bug advocacy

They do not even know what crime has been committed yet!

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Why do we test?

Software testing - DEFINITION

- **Software testing [BBST]** - is an empirical technical investigation conducted to provide stakeholders with information about the quality of the product or service under test
- **False/incomplete definitions**
  - Testing is the process of demonstrating that errors are not present. “Testing can only reveal the presence of errors, never their absence.” [Dij75]
  - The purpose of testing is to show that a program performs its intended functions correctly.
  - Testing is the process of establishing confidence that a program does what it is supposed to do.
- **Definition**
  - Testing is the process of executing a program with the intent of finding errors. [Mye04]
    - Human beings tend to be highly goal-oriented.
    - Testing is a destructive process.
    - Successful and unsuccessful.



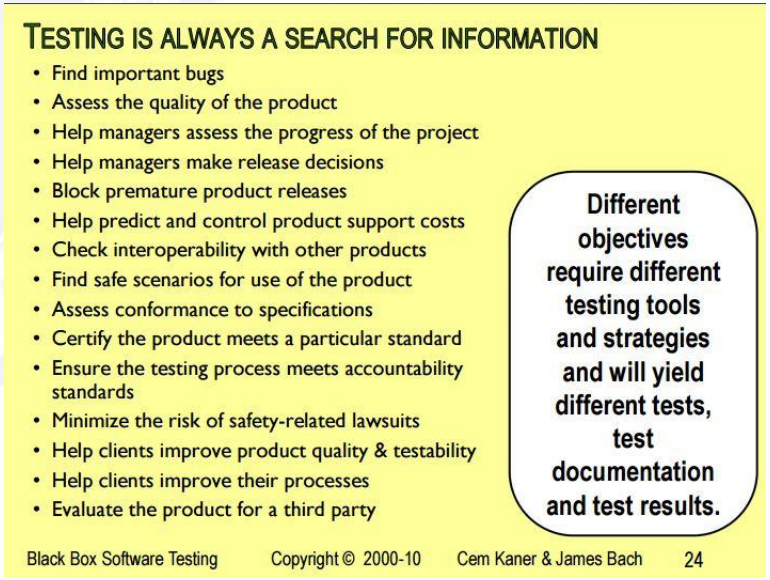
    - Error: the program does not do what it is supposed to do, BUT also if the program does what it is not supposed to do.

Why do we test?

We test a product to learn about its quality. [BBST]

- Everyone tests in context [BBST]
  - Harsh constraints
    - Complete testing is impossible
    - Finite project schedules and budget
    - Limited skills of the test group
  - Do testing – before/during/after – release
  - Improvement of product – might/might not be an objective of testing
  - Test in behalf of stakeholders
    - Project manager/customer/programmer/attorney

- A search for information [BBST]
  - **Question:** What kind of information are we most concerned about learning from this testing?
  - **Answer:** Our information objectives.



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How do we test?

Testing … in context

Context 1.

The teacher asked a group of students (development team) to design and implement a Java application for the given statement problem. The teacher just want to verify the students 's design and implementation skills.

You are working as a tester, and you are assigned to the development team early in the project. The project manager (i.e., the teacher) wants you to test along with the programmers as they write code. She wants you to help the programmers deliver clean code and she wants to help her, and her staff identify, understand and control the implementation.

Context 2.

The teacher asked a group of students (development team) to design and implement a Java application for the given statement problem. The teacher just want to verify the students 's design and implementation skills.

You are working as a tester, and you are assigned to the development team when all the required stated functionalities were implemented and individually tested. The project manager (i.e., the teacher) wants you to test the integration of the implemented functionalities.

Context 3.

The teacher asked a group of students (development team) to design and implement a Java application for the given statement problem. The resulted application will be used by the doctors in their university and by other family doctors.

You are working as a tester, and you are assigned to the development team close to the project's release date. The doctors expected it to work, and they needed to work well. The project manager (i.e., the teacher) expects you to test the product in ways that will help her understand whether the product is ready to release or not.

How do we test?

Strategy/Approach/Technique

- **Strategy definition** (https://en.oxforddictionaries.com/definition/strategy)
  - A plan of action designed to achieve a long-term or overall aim.
- **Approach definition** (http://www.dictionary.com/browse/approach)
  - the method used or steps taken in setting about a task, problem
- **Technique definition** (http://www.dictionary.com/browse/approach)
  - technical skill; ability to apply procedures or methods so as to effect a desired result

- **Testing strategy** = guiding framework for deciding what tests (what test techniques) are best suited to your product.
- **Approach = a way of thinking about …**
- **Technique = methods used to …**

How do we test?

Testing strategies [BBST]

- **Testing strategy is:**
  - The guiding framework for deciding what tests (what test techniques) are best suited to your product.
- **Context** and **information objectives** are (or should be) the drivers of any **testing strategy.**

- **Examples of context factors that drive and constrain testing**
  - Who are the stakeholders with influence?
  - What are the goals and quality criteria for the project?
  - What skills and resources (time, money, tools, data, etc) are available?
  - Potential consequences of potential failures?
  - How could it fail?

- **Common information objectives**
  - Find important bugs
  - Asses the quality of the product
  - Help managers make release decisions
  - Block premature product releases
  - Assess conformance to the specification
  - Find safe scenarios for the use of the product
  - Evaluate the product for a third party

How do we test?

Testing strategies [BBST]

- **Context** and **information objectives** are (or should be) the drivers of any **testing strategy.**

Selecting the Testing techniques ?

Techniques differ in core.

Attributes of "good" tests

- *Power*
- *Valid*
- *Value*
- *Credible*
- *Representative*
- *Non-redundant*
- *Motivating*
- *Reusable*
- *Performable*
- *Maintainable*
- *Information value*
- *Coverage*
- *Easy to evaluate*
- *Support troubleshooting*
- *Appropriately complex*
- *Accountable*
- *Affordable*
- *Opportunity cost*

How do we test?

Strategy/Approach/Technique (revisited)

Selecting the Testing techniques ?

http://www.testingeducation.org/BBST/testdesign/

- ***http://www.testingeducation.org/BBST/testdesign/BBSTTestDesign2011pfinal.pdf***
- ***Slides 67 to 72***
- COVERAGE-BASED TECHNIQUES FOCUS ON WHAT GETS TESTED
- TESTER-BASED TECHNIQUES FOCUS ON WHO DOES THE TESTING
- RISK-BASED TECHNIQUES FOCUS ON POTENTIAL PROBLEMS
- ACTIVITY-BASED TECHNIQUES FOCUS ON HOW YOU DO THE TESTING
- EVALUATION-BASED TECHNIQUES FOCUS ON YOUR ORACLE
- DESIRED-RESULT TECHNIQUES FOCUS ON A SPECIFIC DECISION OR DOCUMENT
- THERE ARE ALSO GLASS-BOX TECHNIQUES

Testing - fundamental questions

- What skills do we need to have to test?

- Why do we test?
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- When we test?

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How do we organize the process of testing?

Test planning

- Test plan?
  - testers communicate what they intend to do.
  - takes the form of a written document, not only the creation of the document, but also planning the testing tasks.
  - The ultimate goal of test planning process is communicating the software test team's intend, expectations, understanding.

- Test planning topics
  - A test plan template? Important topics?
    - The test team's high-level expectations
    - People, places and things, Definitions
    - Inter-group responsibilities
    - What will and won't be tested
    - Test phases, test strategy, Resource requirements
    - Tester assignments
    - Test schedule, Test cases
    - Bug reporting

- Reasons for planning test cases
  - Organization
  - Repeatability
  - Tracking
  - Proof of testing

- VerVal matrix

How do we organize the process of testing?

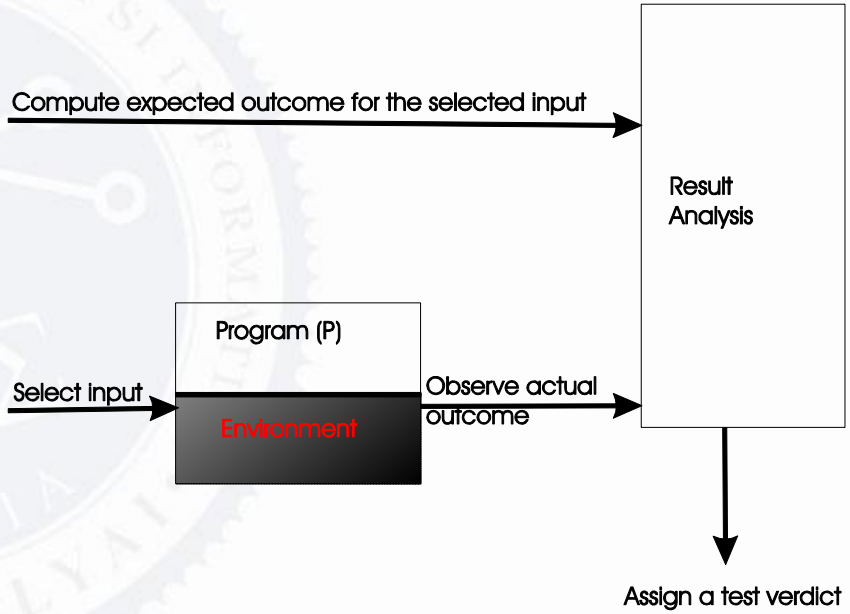
Test case

- Test case < i , r >
  - i domain D
  - r domain R.
  - for input i the expected result is r.
- Test case: “ A set of test inputs, execution conditions, and expected results developed for a particular objective, such as to exercise a particular program path or to verify compliance with a specific requirement.” [IEE90]
- “Good” test case attributes:
  - High probability of finding an error.
  - Is not redundant.
  - “Best of breed”.
  - Neither too simple nor too complex.

How do we organize the process of testing?

Testing activities [NTO5]

- Identify an objective to be tested.
- Select inputs.
- Compute the expected outcome.
- Set up the execution environment of the program.
- Execute the program.
- Analyze the test result.



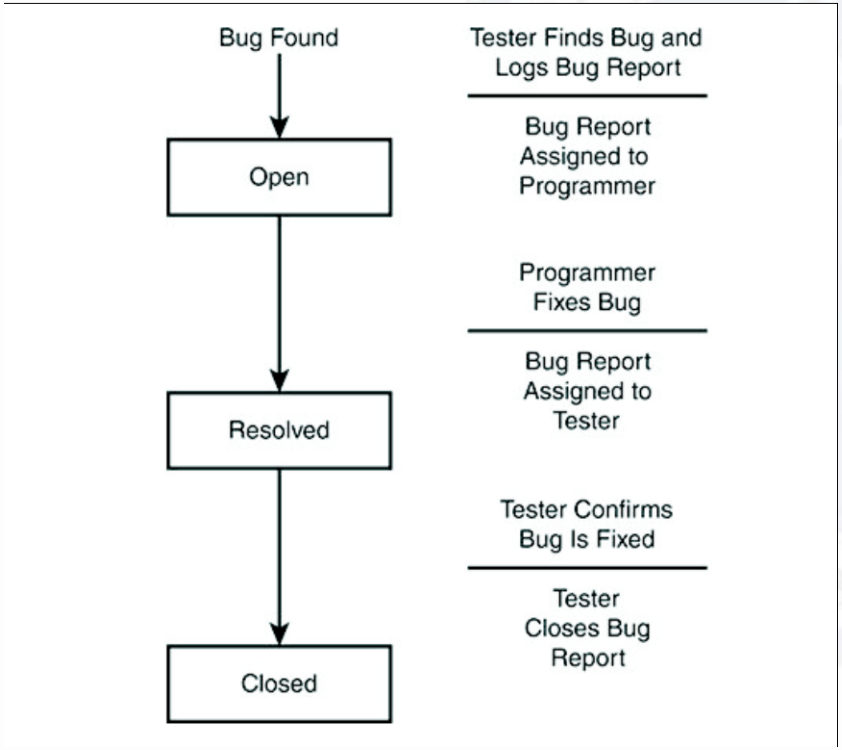
How do we organize the process of testing?

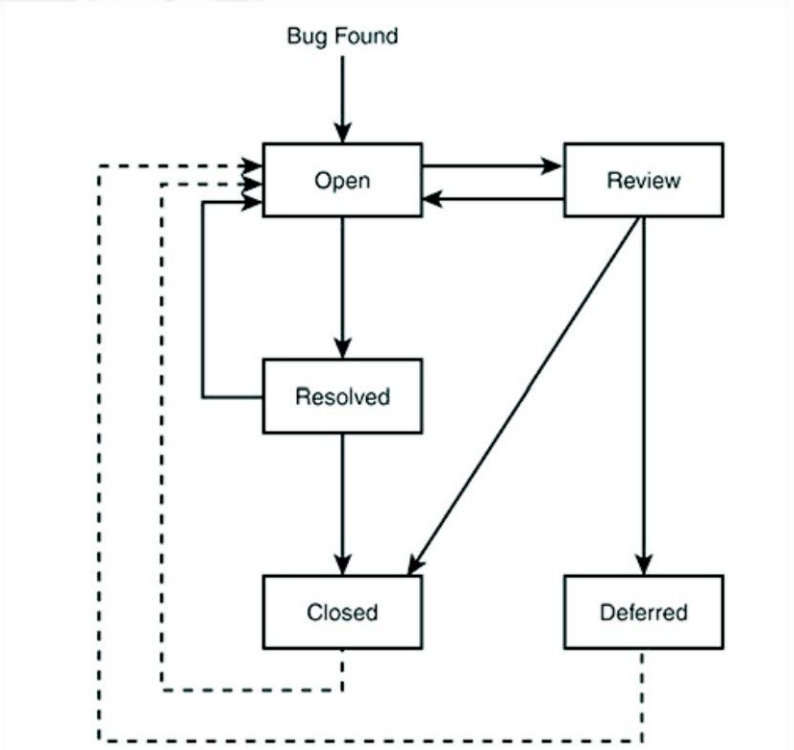
Reporting a bug

- Principles for reporting a bug [Pat05]
  - Report bugs as soon as possible
  - Effectively describe the bugs
  - Be nonjudgmental in reporting bugs
  - Follow up on your bug reports
- Isolating and reproducing bugs [Pat05] - suggestions in isolating a bug
  - Don’t take anything for granted
  - Look for time-dependent and race condition problems
  - White-box issues of boundary condition bugs, memory leaks, data overflows.
  - State bug
  - Resource dependencies and interactions with memory, network, hardware sharing.
  - Don’t ignore the hardware

How do we organize the process of testing?

A bug's Life Cycle [Pat05]





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When have we tested enough?

Program under test

- Program P [Fre10]
- P : D → R, where:
  - D - set of input data;
  - R - set of output data.

Types of testing [Fre10]

- Exhaustive testing - all the possible inputs.
  - if D is finite, then P is executed for all possible inputs.
- Selective testing
  - if D is not finite, then we choose inputs i from S (included in D).

- Cem Kaner, The Impossibility of Complete Testing, http://www.testingeducation.org/BBST/foundations/Kaner_impossibility.pdf

When have we tested enough?

Required reading (before Seminar 2)

Testing principles [Mye04]

- Definition of the expected output or result;
- Avoid testing your own program.
- A programming organization should not test its own programs.
- Thoroughly inspect the results of each test.
- Test cases for valid/invalid input conditions.
- Test if the program does not do what it is supposed to do, AND if the program does what it is not supposed to do.
- Do not throwaway test cases.
- Plan testing assuming errors will be found.
- 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.
- Testing is an extremely creative and intellectually challenging task.
- **Remark:** Principles rewritten in [CB03].

Testing axioms [Pat05]

- It is impossible to test a program completely.
- Software testing is a risk-based exercise.
- Testing can't show that bugs don't exist.
- The more bugs you find, the more bugs there are.
- The pesticide paradox.
- Not all the bugs you find will be fixed.
- When a bug's a bug it is difficult to say.
- Product specification are never final.
- Software testers aren't the most popular member of a project team.
- Software testing is a disciplined technical profession.

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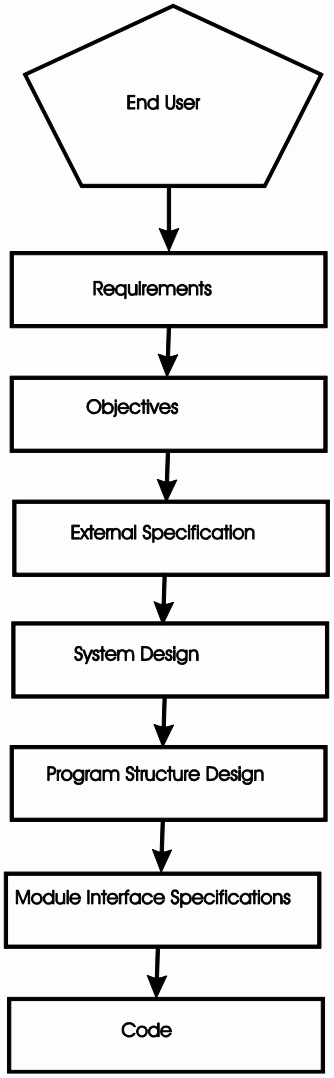
When we test?

Software development process

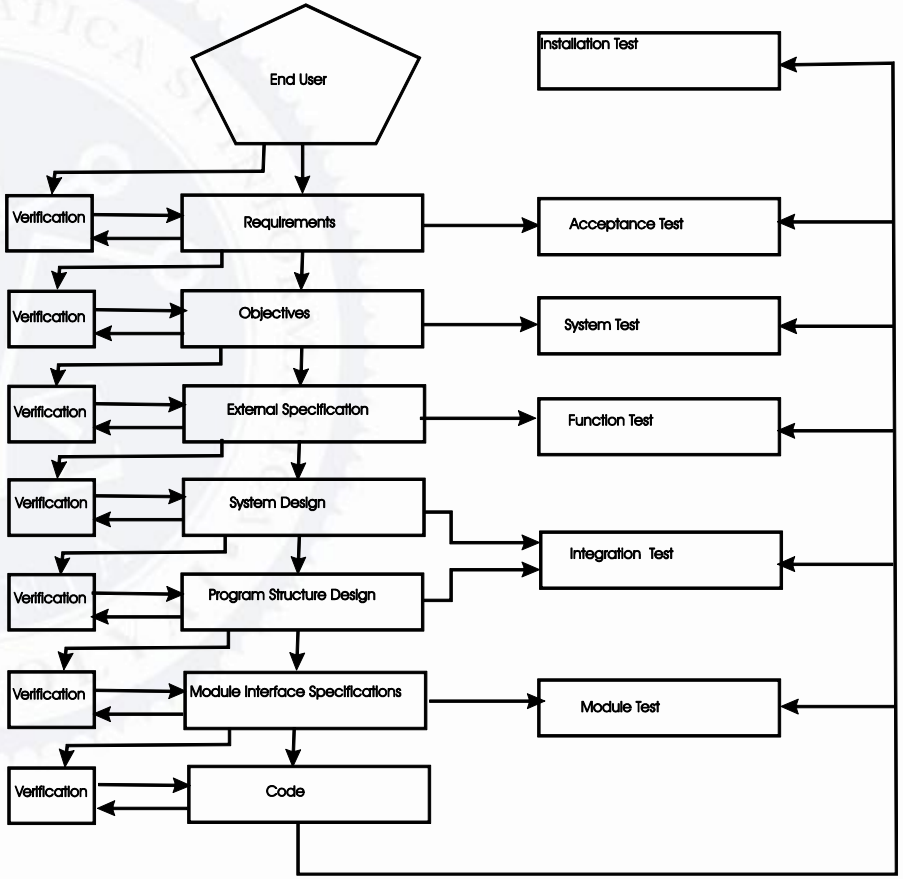
- user's needs are translated into requirements
- requirements are translated into objectives
- objectives are translated into external specification
- system design
- program structure design
- module interface specification
- code



When we test?

Development and testing processes

- Approaches to prevent errors:
  - More precision into the development process.
  - Introduction of a verification step at the end of each process.
  - Orient distinct testing processes toward distinct development processes.



When we test?

Levels of testing

Unit testing

- Testing individual subprograms, subroutines, procedures, the smaller building blocks of the program.
- **Motivations**:
  - Managing the combined elements of testing.
  - Module testing eases the task of debugging.
  - Module testing introduces parallelism into the program testing process.
- **Points of view**
  - The manner in which test cases are designed.
  - The order in which modules should be tested and integrated.
- Advice about performing the test.

- References: [Mye04] (chapter 5),[NT05] (chapter 3).

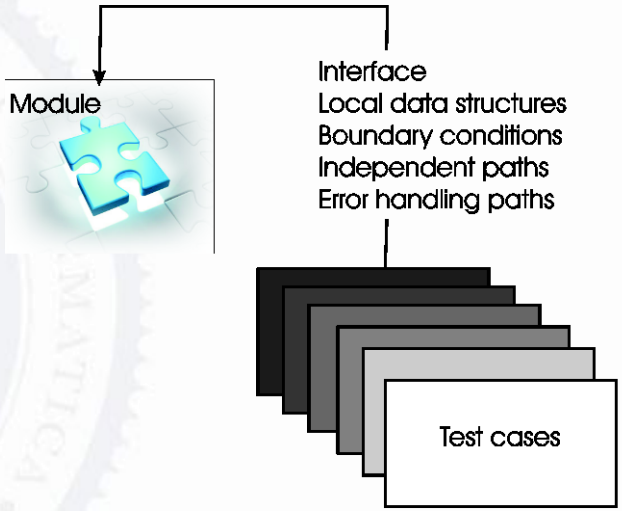
When we test?

Levels of testing

Unit testing

Test case design

- Information needed when designing test cases for a module:
  - specification of the module
  - the module's source code
- Test case design procedure for a module test is:
  - Analyze the logic of the module using white-box methods.
  - Applying black-box methods to the module's specification.



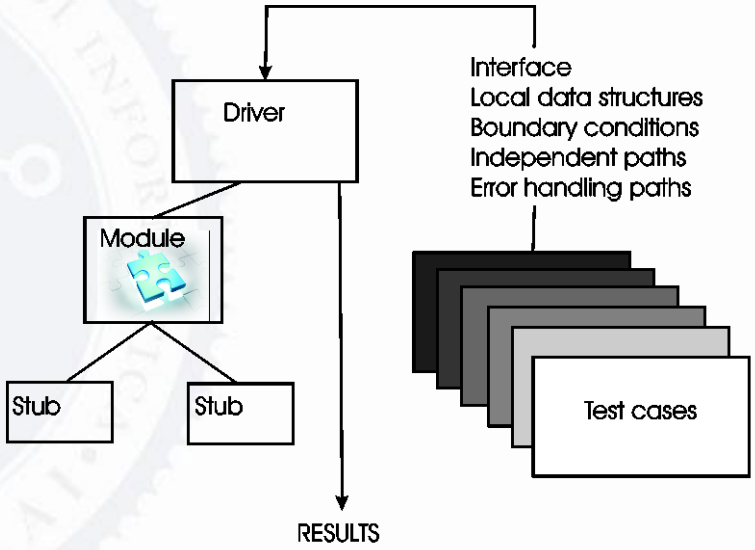
When we test?

Levels of testing

Unit testing

Unit test procedures

- Unit test environment
  - **driver** - a ”main program” that accepts test case data, passes such data to the component to be tested and prints relevant results;
  - **stub** - serve to replace modules that are subordinate the component to be tested.
    - uses the subordinate module’s interface
    - may do minimal data manipulation
    - prints verification of entry
    - returns control to the module undergoing testing.



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- [Fre10] M. Frentiu, Verificarea si validarea sistemelor soft, Presa Universitara Clujeana, 2010
- [BBST] BBST Testing course, http://testingeducation.org/BBST/
  - **Foundations of Software Testing,**
    - **Lecture 2: Strategy**
    - **Lecture 5: The Impossibility of Complete Testing**

Next Lecture

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- Continuous integration - Jenkins

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