Software testing and TDD

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Topics covered

◇ Development testing

◇ Test-driven development

Program testing

◇ Testing is intended to show that a program does what it is intended to do and to discover program defects before it is put into use.

◇ When you test software, you execute a program using artificial data.

◇ You check the results of the test run for errors, anomalies or information about the program's non-functional attributes.

◇ Can reveal the presence of errors NOT their absence.

◇ Testing is part of a more general verification and validation process, which also includes static validation techniques.

Program testing goals

◇ To demonstrate to the developer and the customer that the software meets its requirements.

  ▪ For custom software, this means that there should be at least one test for every requirement in the requirements document. For generic software products, it means that there should be tests for all of the system features, plus combinations of these features, that will be incorporated in the product release.

◇ To discover situations in which the behavior of the software is incorrect, undesirable or does not conform to its specification.

  ▪ Defect testing is concerned with rooting out undesirable system behavior such as system crashes, unwanted interactions with other systems, incorrect computations and data corruption.

Validation and defect testing

◇ The first goal leads to validation testing

- You expect the system to perform correctly using a given set of test cases that reflect the system's expected use.

◇ The second goal leads to defect testing

- The test cases are designed to expose defects. The test cases in defect testing can be deliberately obscure and need not reflect how the system is normally used.

Testing process goals

◇ Validation testing
  - To demonstrate to the developer and the system customer that the software meets its requirements
  - A successful test shows that the system operates as intended.

◇ Defect testing
  - To discover faults or defects in the software where its behaviour is incorrect or not in conformance with its specification
  - A successful test is a test that makes the system perform incorrectly and so exposes a defect in the system.

An input-output model of program testing
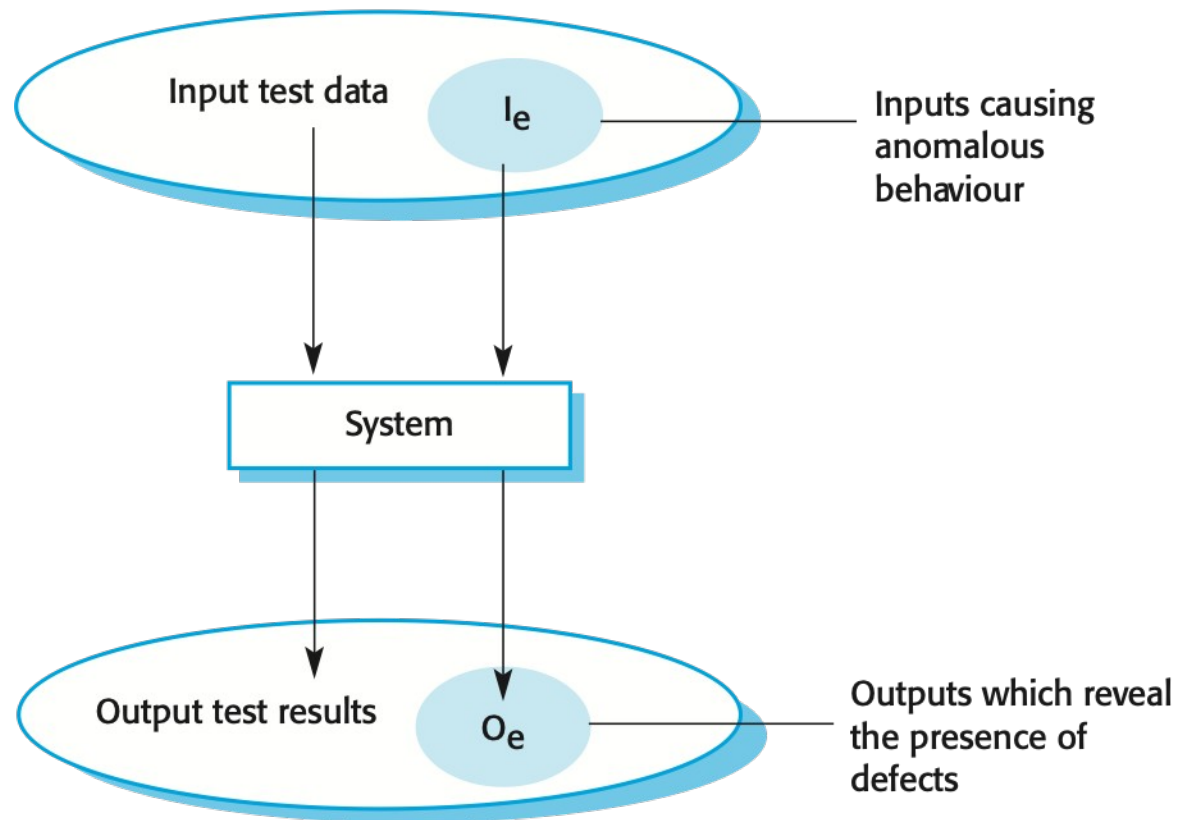
Verification vs validation

◇ Verification:

"Are we building the product right".

◇ The software should conform to its specification.

◇ Validation:

"Are we building the right product".

◇ The software should do what the user really requires.

V & V confidence

◇ Aim of V & V is to establish confidence that the system is 'fit for purpose'.

◇ Depends on system's purpose, user expectations and marketing environment

- Software purpose
  - The level of confidence depends on how critical the software is to an organisation.
- User expectations
  - Users may have low expectations of certain kinds of software.
- Marketing environment
  - Getting a product to market early may be more important than finding defects in the program.

Inspections and testing

◇ **Software inspections** Concerned with analysis of the static system representation to discover problems (static verification)

- May be supplement by tool-based document and code analysis.

◇ **Software testing** Concerned with exercising and observing product behaviour (dynamic verification)

- The system is executed with test data and its operational behaviour is observed.

Inspections and testing
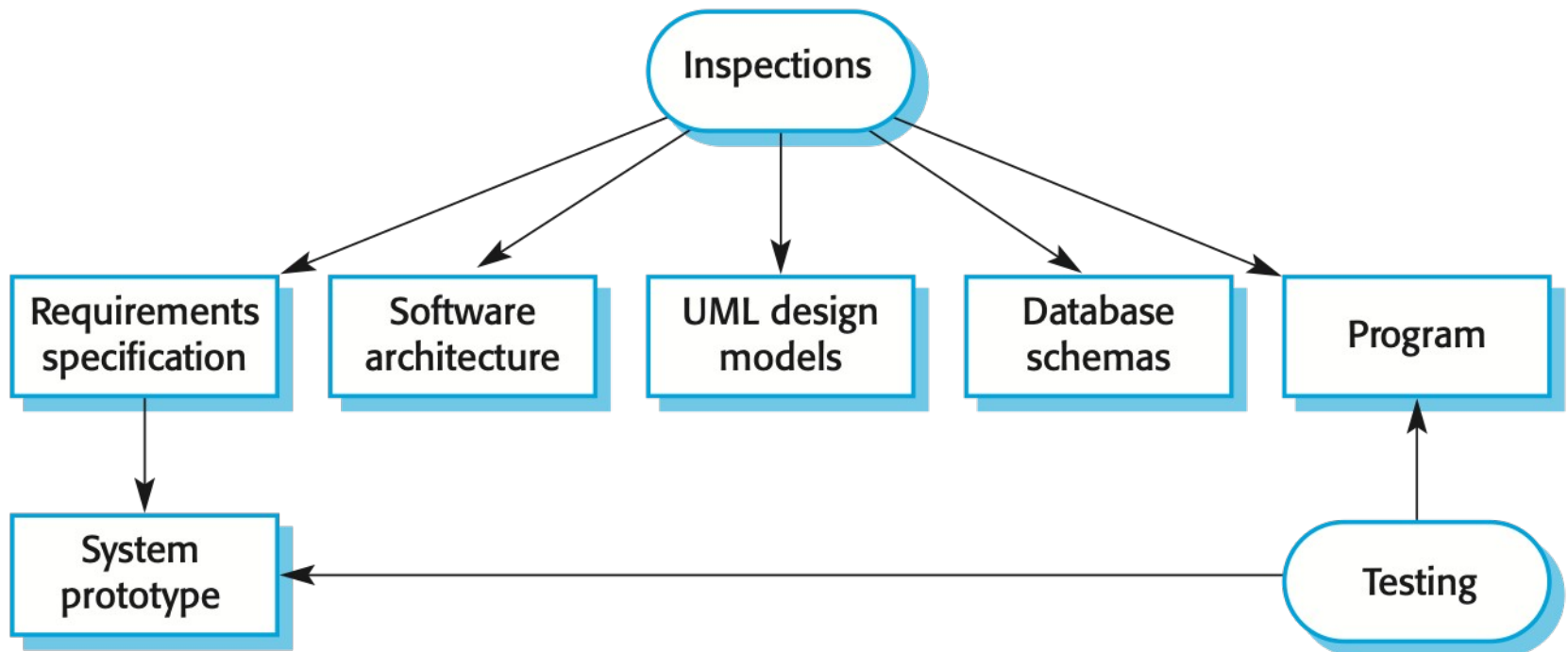
Software inspections

◇ These involve people examining the source representation with the aim of discovering anomalies and defects.

◇ Inspections not require execution of a system so may be used before implementation.

◇ They may be applied to any representation of the system (requirements, design,configuration data, test data, etc.).

◇ They have been shown to be an effective technique for discovering program errors.

Advantages of inspections

◇ During testing, errors can mask (hide) other errors. Because inspection is a static process, you don't have to be concerned with interactions between errors.

◇ Incomplete versions of a system can be inspected without additional costs. If a program is incomplete, then you need to develop specialized test harnesses to test the parts that are available.

◇ As well as searching for program defects, an inspection can also consider broader quality attributes of a program, such as compliance with standards, portability and maintainability.

Inspections and testing

◇ Inspections and testing are complementary and not opposing verification techniques.

◇ Both should be used during the V & V process.

◇ Inspections can check conformance with a specification but not conformance with the customer's real requirements.

◇ Inspections cannot check non-functional characteristics such as performance, usability, etc.

A model of the software testing process
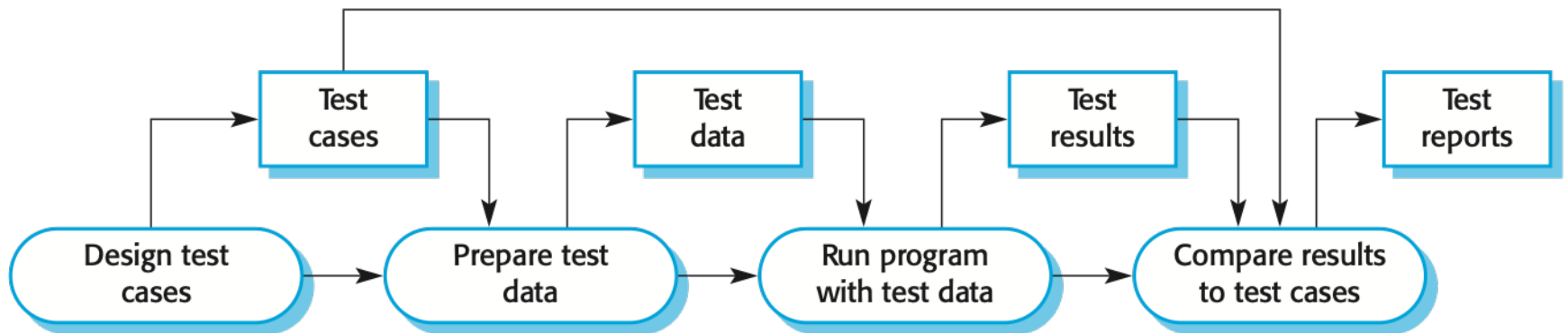
Stages of testing

◇ **Development testing**, where the system is tested during development to discover bugs and defects.

◇ **Release testing**, where a separate testing team test a complete version of the system before it is released to users.

◇ **User testing**, where users or potential users of a system test the system in their own environment.

Development testing

◇ Development testing includes all testing activities that are carried out by the team developing the system.

- Unit testing, where individual program units or object classes are tested. Unit testing should focus on testing the functionality of objects or methods.

- Component testing, where several individual units are integrated to create composite components. Component testing should focus on testing component interfaces.

- System testing, where some or all of the components in a system are integrated and the system is tested as a whole. System testing should focus on testing component interactions.

Unit testing

◇ Unit testing is the process of testing individual components in isolation.

◇ It is a defect testing process.

◇ Units may be:
  ▪ Individual functions or methods within an object
  ▪ Object classes with several attributes and methods
  ▪ Composite components with defined interfaces used to access their functionality.

Object class testing

◇ Complete test coverage of a class involves

- Testing all operations associated with an object
- Setting and interrogating all object attributes
- Exercising the object in all possible states.

◇ Inheritance makes it more difficult to design object class tests as the information to be tested is not localised.

Automated testing

◇ Whenever possible, unit testing should be automated so that tests are run and checked without manual intervention.

◇ In automated unit testing, you make use of a test automation framework (such as JUnit) to write and run your program tests.

◇ Unit testing frameworks provide generic test classes that you extend to create specific test cases. They can then run all of the tests that you have implemented and report, often through some GUI, on the success of otherwise of the tests.

Automated test components

◇ A setup part, where you initialize the system with the test case, namely the inputs and expected outputs.

◇ A call part, where you call the object or method to be tested.

◇ An assertion part where you compare the result of the call with the expected result. If the assertion evaluates to true, the test has been successful if false, then it has failed.

Unit test effectiveness

◇ The test cases should show that, when used as expected, the component that you are testing does what it is supposed to do.

◇ If there are defects in the component, these should be revealed by test cases.

◇ This leads to 2 types of unit test case:

- The first of these should reflect normal operation of a program and should show that the component works as expected.

- The other kind of test case should be based on testing experience of where common problems arise. It should use abnormal inputs to check that these are properly processed and do not crash the component.

Testing guidelines (sequences)

◇ Test software with sequences which have only a single value.

◇ Use sequences of different sizes in different tests.

◇ Derive tests so that the first, middle and last elements of the sequence are accessed.

◇ Test with sequences of zero length.

General testing guidelines

◇ Choose inputs that force the system to generate all error messages

◇ Design inputs that cause input buffers to overflow

◇ Repeat the same input or series of inputs numerous times

◇ Force invalid outputs to be generated

◇ Force computation results to be too large or too small.

Key points

◇ Testing can only show the presence of errors in a program. It cannot demonstrate that there are no remaining faults.

◇ Development testing is the responsibility of the software development team. A separate team should be responsible for testing a system before it is released to customers.

◇ Development testing includes unit testing, in which you test individual objects and methods component testing in which you test related groups of objects and system testing, in which you test partial or complete systems.

Component testing

◇ Software components are often composite components that are made up of several interacting objects.

- For example, in the weather station system, the reconfiguration component includes objects that deal with each aspect of the reconfiguration.

◇ You access the functionality of these objects through the defined component interface.

◇ Testing composite components should therefore focus on showing that the component interface behaves according to its specification.

- You can assume that unit tests on the individual objects within the component have been completed.

Interface testing
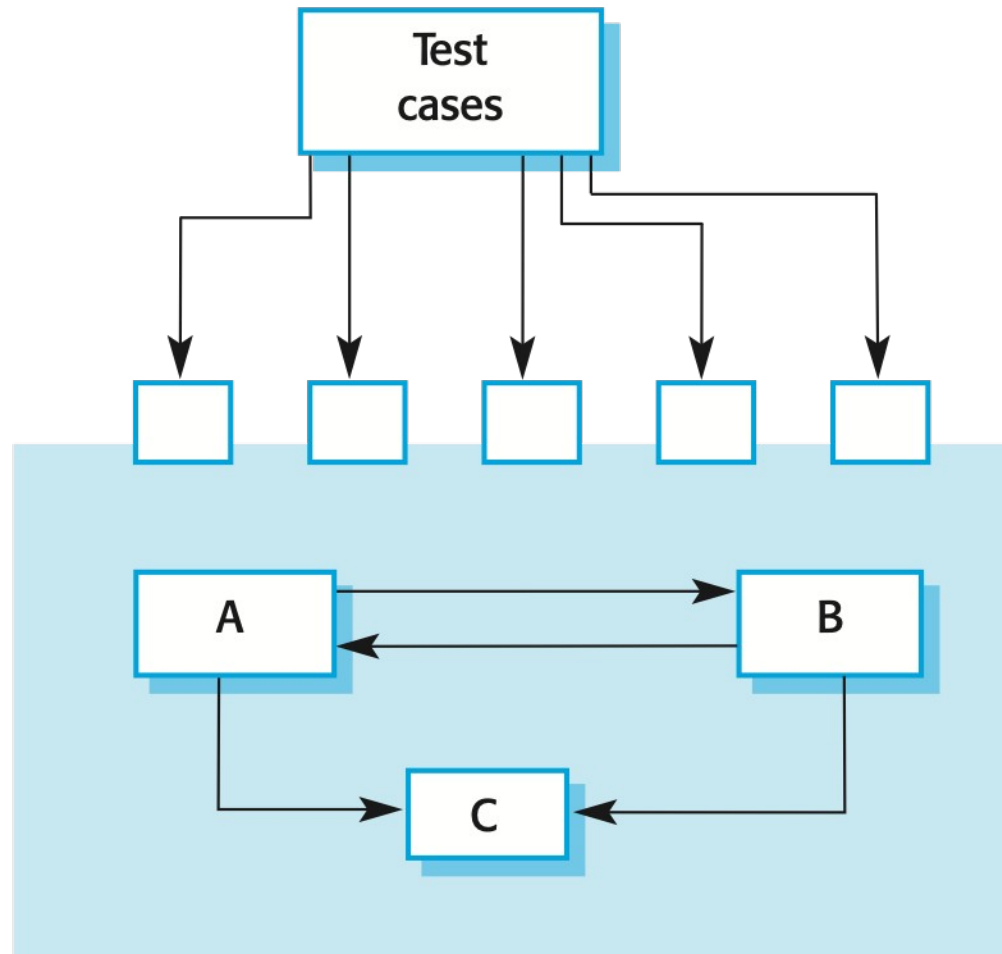
Interface testing

◇ Objectives are to detect faults due to interface errors or invalid assumptions about interfaces.

◇ Interface types

- **Parameter interfaces** Data passed from one method or procedure to another.

- **Shared memory interfaces** Block of memory is shared between procedures or functions.

- **Procedural interfaces** Sub-system encapsulates a set of procedures to be called by other sub-systems.

- **Message passing interfaces** Sub-systems request services from other sub-systems

Interface errors

◇ **Interface misuse**
- A calling component calls another component and makes an error in its use of its interface e.g. parameters in the wrong order.

◇ **Interface misunderstanding**
- A calling component embeds assumptions about the behaviour of the called component which are incorrect.

◇ **Timing errors**
- The called and the calling component operate at different speeds and out-of-date information is accessed.

Interface testing guidelines

◇ Design tests so that parameters to a called procedure are at the extreme ends of their ranges.

◇ Always test pointer parameters with null pointers.

◇ Design tests which cause the component to fail.

◇ Use stress testing in message passing systems.

◇ In shared memory systems, vary the order in which components are activated.

System testing

◇ System testing during development involves integrating components to create a version of the system and then testing the integrated system.

◇ The focus in system testing is testing the interactions between components.

◇ System testing checks that components are compatible, interact correctly and transfer the right data at the right time across their interfaces.

◇ System testing tests the emergent behaviour of a system.

System and component testing

◇ During system testing, reusable components that have been separately developed and off-the-shelf systems may be integrated with newly developed components. The complete system is then tested.

◇ Components developed by different team members or sub-teams may be integrated at this stage. System testing is a collective rather than an individual process.

  ▪ In some companies, system testing may involve a separate testing team with no involvement from designers and programmers.

Testing policies

◇ Exhaustive system testing is impossible so testing policies which define the required system test coverage may be developed.

◇ Examples of testing policies:

- All system functions that are accessed through menus should be tested.
- Combinations of functions (e.g. text formatting) that are accessed through the same menu must be tested.
- Where user input is provided, all functions must be tested with both correct and incorrect input.

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◇ TDD was introduced as part of agile methods such as Extreme Programming. However, it can also be used in plan-driven development processes.

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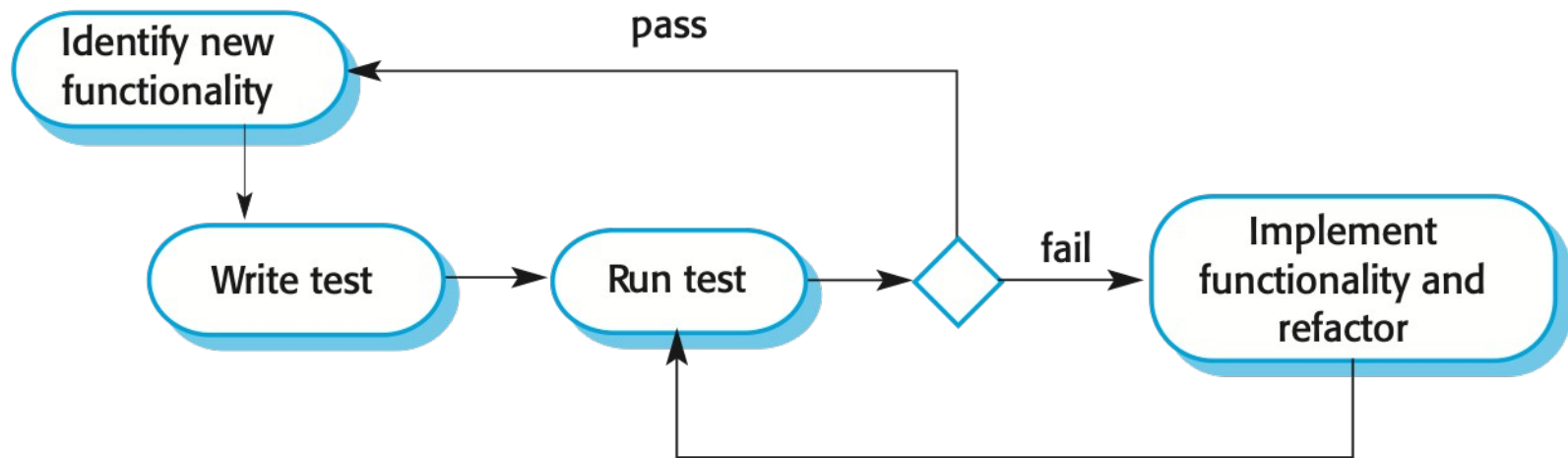
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◇ Implement the functionality and re-run the test.

◇ Once all tests run successfully, you move on to implementing the next chunk of functionality.

TDD
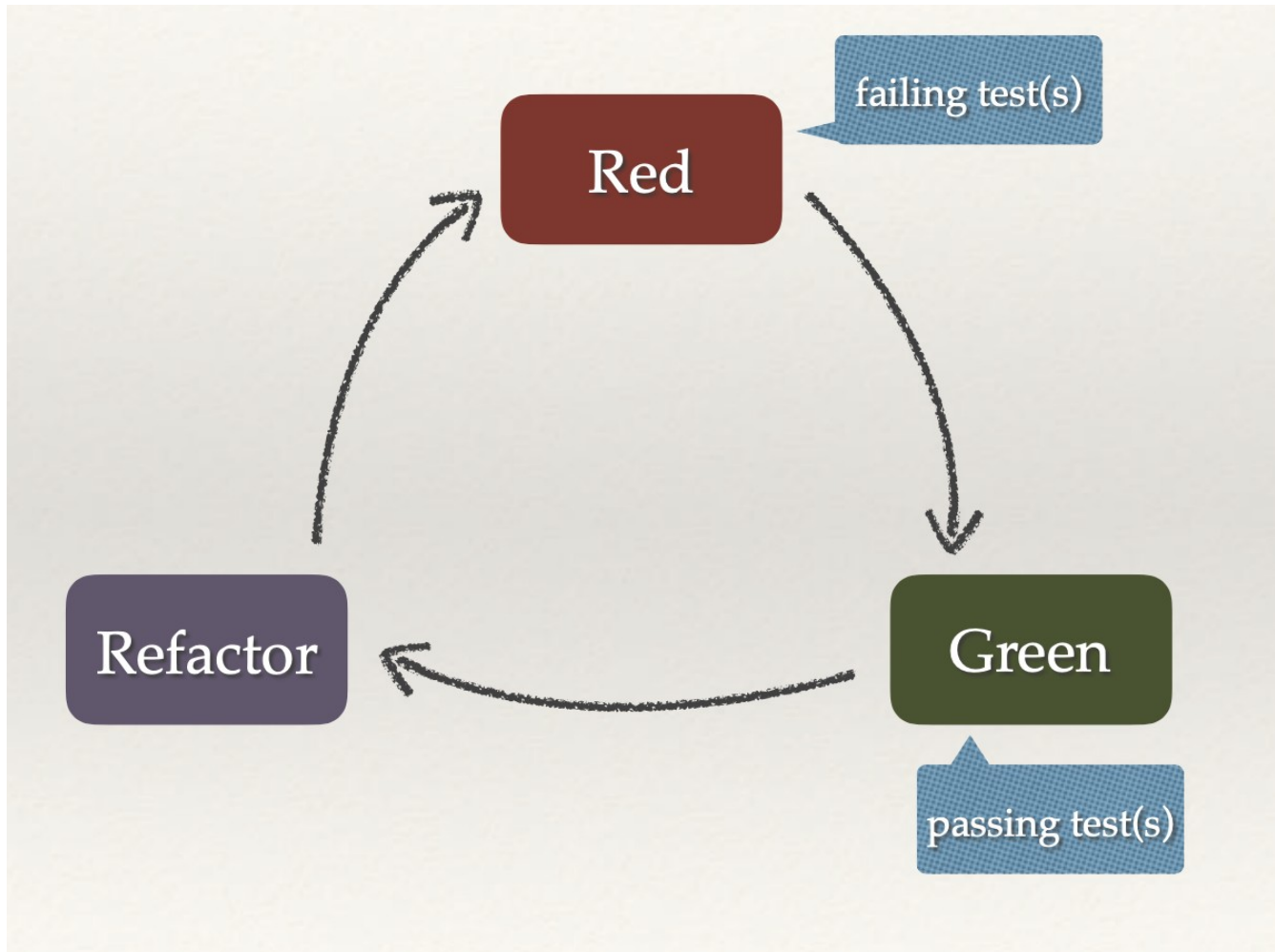
3 laws

◇ **Law 1:** You may not write production code unless you've first written a failing unit test.

◇ **Law 2:** You may not write more of a unit test than is sufficient to fail.

◇ **Law 3:** You may not write more production code than is sufficient to make the failing unit test pass.

(Professionalism and Test-Driven Development, Robert C. Martin, IEEE Software, 2007)

Benefits of test-driven development

◇ **Code coverage**

- Every code segment that you write has at least one associated test so all code written has at least one test.

◇ **Regression testing**

- A regression test suite is developed incrementally as a program is developed.

◇ **Simplified debugging**

- When a test fails, it should be obvious where the problem lies. The newly written code needs to be checked and modified.

◇ **System documentation**

- The tests themselves are a form of documentation that describe what the code should be doing.

Reading

◇ Chapter 8, Software Engineering, Sommerville