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Unscheduled Asynchronous Lesson 1

C206 Software Development Process

Automated Testing and Version Control (ATVC) Part 1

Learning Objective

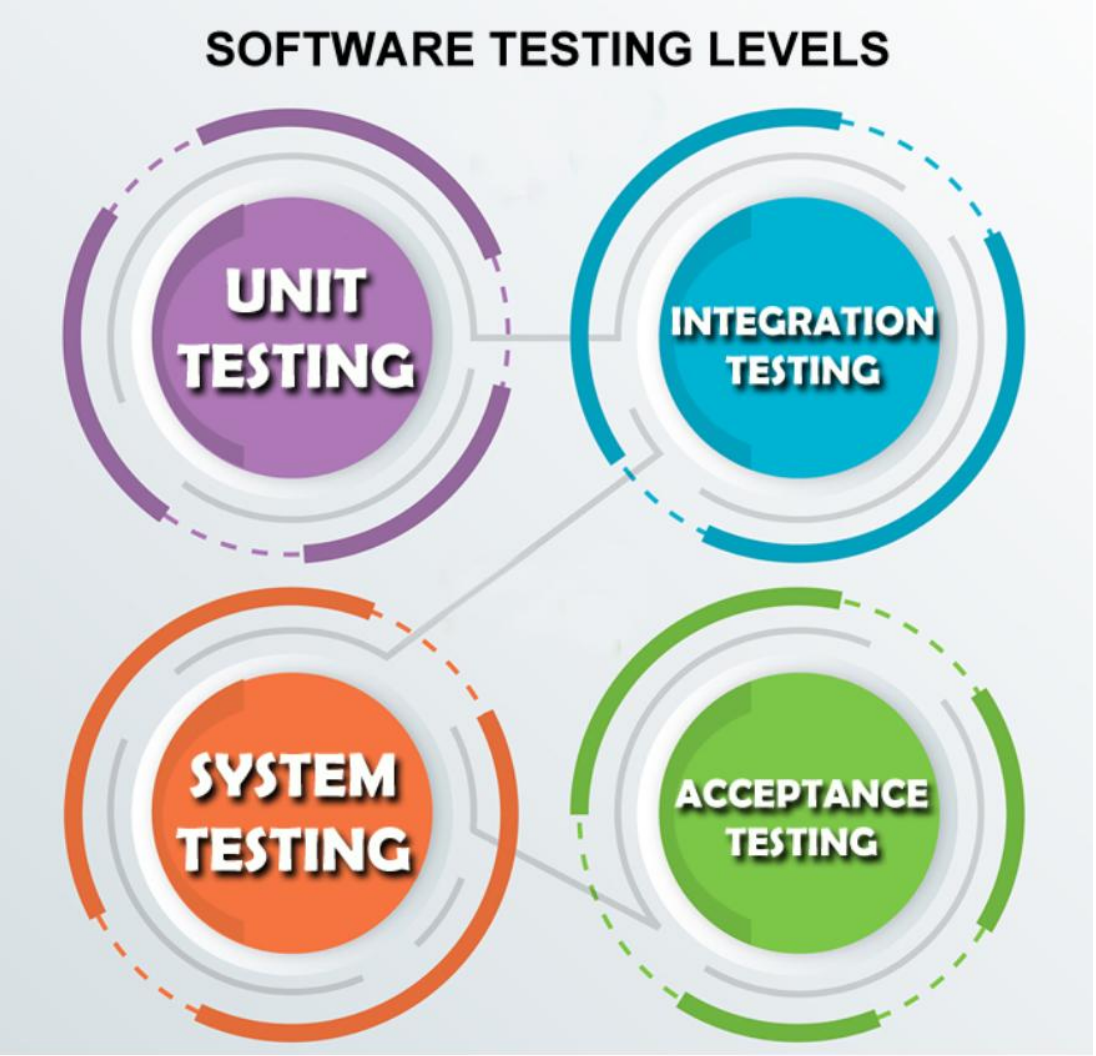
- Analyze the role, characteristics and benefits of unit testing in software quality assurance
- Apply the "Arrange, Act, Assert" pattern to effectively structure unit tests
- Discuss the use of test coverage metrics to assess the comprehensiveness of unit testing
- Configure and use Pytest for writing and automating unit tests

Unit Testing

Software Testing Levels - Role of Unit Testing

- Software testing levels
  1. Unit testing
  2. Integration testing
  3. System testing
  4. Acceptance testing

- Unit testing is the first level of testing
  - It involves testing individual units or components of the software
  - It is performed by developers to ensure that each unit functions correctly and as expected
  - It is fundamental in identifying and fixing bugs early in the development process



Unit Testing in Software Development

- **Focus** - Tests the smallest part of the application, like a method or function
- **Developer-driven** - Written by the same developers who write the application code
- **Early Execution** - Conducted early in the Software Development Life Cycle (SDLC) to catch and fix issues promptly
- **Multiple tests per method** - Covers various scenarios including normal, boundary, and error conditions
- **Automation** - Tests are automated for quick and frequent execution

Benefits of Unit Testing

- **Early Bug Detection** - Finds issues early in the development cycle
- **Facilitates Code Changes** - Safely refactor or update code with less risk
- **Simplifies Integration** - Helps ensure units work correctly before full integration
- **Acts as Documentation** - Shows how the code should work, aiding new team members
- **Improves Code Quality** - Encourages modular and less error-prone coding practices

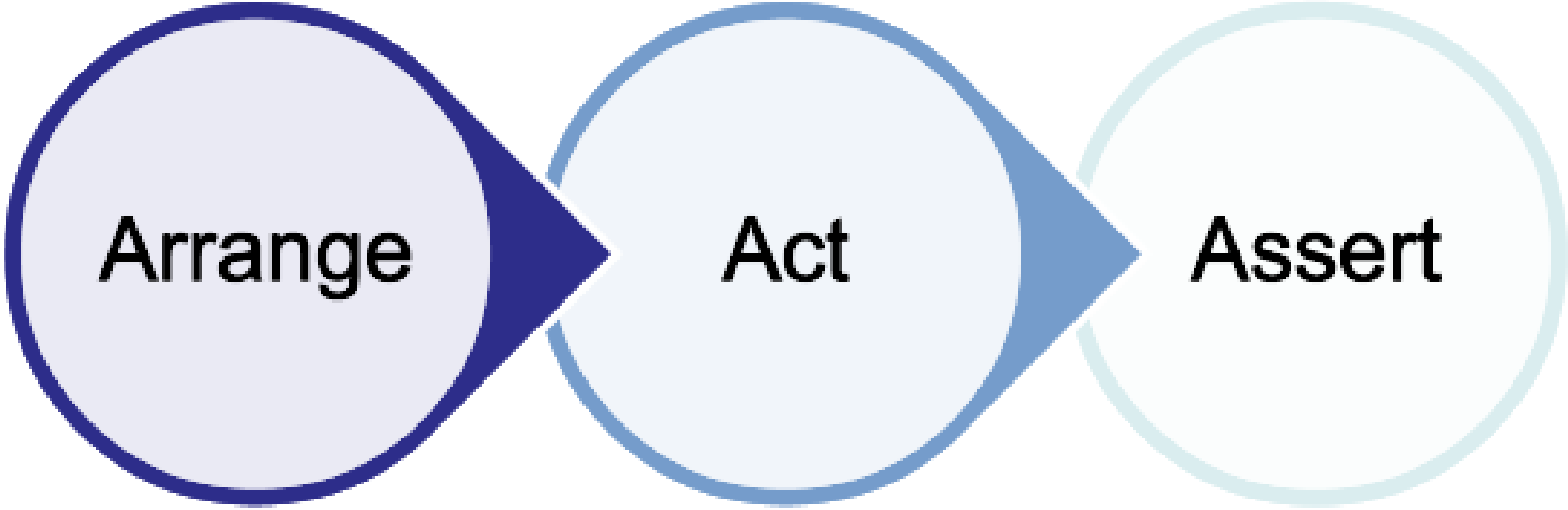
Benefits of Unit Testing

- **Enhances Design** - Promotes thoughtful design before coding
- **Cost-Effective** - Reduces long-term bug fix and maintenance costs
- **Enables Continuous Integration / Delivery -** Crucial for frequent and reliable code updates
- **Speeds Up Development -** Faster, safer code changes in the long run
- **Increases Confidence -** Provides peace of mind about code reliability

Structure of a unit test case - Arrange, Act, Assert

The structure of a typical unit test can be presented by the AAA pattern

Arrange – Act – Assert



Structure of a unit test case - Arrange, Act, Assert

- Arrange
  - Set up the testing environment
  - Initialize objects, variables, mocks, and any prerequisites necessary for the test
  - Prepare the state and inputs for the code to be tested

- Act
  - Perform the test and execute the code to be tested

- Assert
  - Verify the outcome of the Act step
  - Check if the results meets your expectations
  - Assertions are used to compare the actual output of your code against expected values, throwing an error if the test fails

Example of a unit test case - Arrange, Act, Assert

```python
class Calculator:
    def add(self, a, b):
        return a + b

    def subtract(self, a, b):
        return a - b

    def multiply(self, a, b):
        return a * b

    def divide(self, a, b):
        if b == 0:
            raise ZeroDivisionError("Division by zero error")
        return a / b
```

```python
class TestCalculator:
    def test_add(self):

        # arrange
        a = 4321
        b = 1234
        cal = Calculator()

        # act
        result = cal.add(a, b)

        # assert
        expected = 5555
        assert result == expected
```

ARRANGE

ACT

ASSERT

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Summary of Lesson - Arrange, Act, Assert

Unit Test Case phase	Definition	Example (Password checking *)

Arrange	Prepare all necessary preconditions, inputs, and dependencies for the test.	# Arrange
		username = "alice"
		password = "ecila" # reversed username

Act	Invoke the function or method being tested.	# Act
		is_valid = checkPassword(username, password)

Assert	Check that the actual result matches the expected outcome.	# Assert assert is_valid == True

* The method **`checkPassword`** checks the validity of the password based on the username and returns **`True`** if it is valid.

Test coverage

- Test coverage is a metric used in software testing to determine how much of the application has been tested
- It can occur at all 4 testing levels: unit, integration, system, or acceptance
- At the integration level, focus might be on interfaces and interactions
- At the system or acceptance level, focus might be on requirements, menu options, screens, or typical business transactions

Unit Testing - 2 types of coverage

- Statement coverage
  - Measures if every line of code is executed at least once
  - Focus: Identifying unexecuted lines

- Decision coverage
  - Measures if every possible path in a conditional statement is tested
  - Focus: Testing all branches of control structures like 'if', 'else', and 'switch'

Statement Coverage

- Statement coverage is also known as line coverage or segment coverage
- Test requirements : all the statements in the program
- Coverage measure : number of executed statements / total number of statements

- Watch this video https://www.youtube.com/watch?v=9PSrhH2gtkU (3m 42s)

Decision Coverage / Branch Coverage

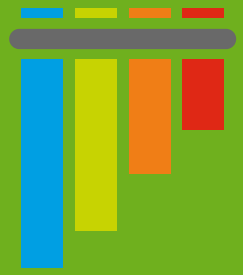
- Decision coverage is also known as branch coverage or all-edges coverage
- Test requirements : all branches in the program
- Coverage measure : number of executed branches / total number of branches

- Watch this video https://www.youtube.com/watch?v=JkJFxPy08rk (4m 17s)

Summary of Lesson – Test Coverage

Test Coverage	Description	Purpose	Measure
Statement Coverage	Measures the percentage of executable statements in the code that have been executed.	To ensure that every line of code has been executed at least once.	(Number of executed statements / Total number of executable statements) * 100%
Decision/Branch Coverage	Measures the percentage of branches (decision outcomes) in the code that have been executed.	To ensure that all possible outcomes of each decision point have been tested.	(Number of executed branches / Total number of branches) * 100%

Introduction To pytest



pytest

Unit testing frameworks

- Most languages offer native or third-party unit testing tools, emphasizing the importance of testing in software development

- Popular unit testing frameworks by programming language
  - Python - pytest, unittest, nose2
  - JavaScript - Jest, Mocha, Jasmine
  - Java - JUnit, TestNG, Mockito
  - C# - NUnit, xUnit.net, MSTest
  - C++ - Google Test, Boost.Test, Catch2
  - Ruby - RSpec, Minitest, Test::Unit
  - PHP - PHPUnit, Behat
  - Go - Go's Testing Package, Ginkgo, Testify
  - Swift / Objective-C - XCTest, Quick/Nimble
  - Kotlin / Android - JUnit, Espresso, MockK

pytest

https://pytest.org/

- The pytest framework makes it easy to write small, readable tests, and can scale to support complex functional testing for applications and libraries
- pytest requires: **Python 3.8+** or PyPy3

- Installation
  - pip install pytest

- Version check
  - pytest --version

- Running the tests
  - pytest

pytest - Test discovery

- Complete documentation
  - https://docs.pytest.org/en/8.0.x/explanation/goodpractices.html

Simplified and incomplete version

- pytest implements the following standard test discovery:
  - Recurse into directories in the current directory
  - In those directories, search for `test_*.py` or `*_test.py` files
  - From those files, collect test items:
    - `test` prefixed test functions or methods outside of class
    - `test` prefixed test functions or methods inside `Test` prefixed test classes

Passing the pytest

- A test function passes if the value being asserted evaluates to `True`
- In this example, `pytest` found 2 test files
  - `test_file_1.py` with 3 tests (3 dots) which passed
  - `test_sample.py` with 1 test (1 dot) which passed
- The less output you see, the better
  - no news is good news

Failing the pytest

- A test function fails if the value being asserted evaluates to `False`
- In this example, test_sample.py had
  - 1 test assed (one dot)
  - 1 test which failed with an AssertionError at line 5 of `test_sample.py` (one red 'F')
- Refer to this page for a demo of Python failure reports with pytest

Examples of tests which pass and fail

```
# the following tests all pass
def test_assert_true():
    assert True

def test_assert_int_value_equality():
    x = 4
    y = 4
    assert x == y

def test_assert_value_equality():
    x = 4.0
    y = 4
    assert x == y

def test_assert_bool_value_equality():
    x = False
    y = 3 == 4
    assert x == y
```

```
# the following tests all fail
def test_assert_false():
    assert False

def test_assert_int_value_inequality():
    x = 3
    y = 4
    assert x == y

def test_assert_value_inequality():
    x = 4.1
    y = 4
    assert x == y

def test_assert_bool_value_inequality():
    x = True
    y = 3 == 4
    assert x == y
```

coverage.py to measure Test Coverage

Coverage report: 75%

filter...

coverage.py v7.4.4, created at 2024-04-09 19:15 +0800

Module	*statements*	*missing*	*excluded*	*branches*	*partial*	*coverage*
calculator/__init__.py	0	0	0	0	0	100%
calculator/calculator.py	11	5	0	2	0	46%
tests/__init__.py	0	0	0	0	0	100%
tests/test_calculator.py	15	0	0	0	0	100%
Total	**26**	**5**	**0**	**2**	**0**	**75%**

coverage.py v7.4.4, created at 2024-04-09 19:15 +0800

- `Coverage.py` is a tool for measuring statement coverage and branch coverage of Python programs

- https://coverage.readthedocs.io/en/latest/index.html
- https://coverage.readthedocs.io/en/latest/branch.html

- pip install coverage
- coverage run --branch -m pytest
- coverage report -m
- coverage html

Thank you!