

TESTING

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WHITE AND BLACK BOX TESTING

- › White box testing – typically during development
 - Access to code
 - Access to development environment
- › Black box testing
 - Internal structure of the code is not known/interested
 - Checks the communication between the tested entity and its environment
 - IUT/SUT – Implementation/System Under Test
 - Tester – may be decomposed
 - PCO – Point of Control and Observation

BLACK BOX TESTING

› Black box testing

- Implementation/System Under Test
- Point of Control and Observation



› Not possible to test all the situations

- Test Purposes

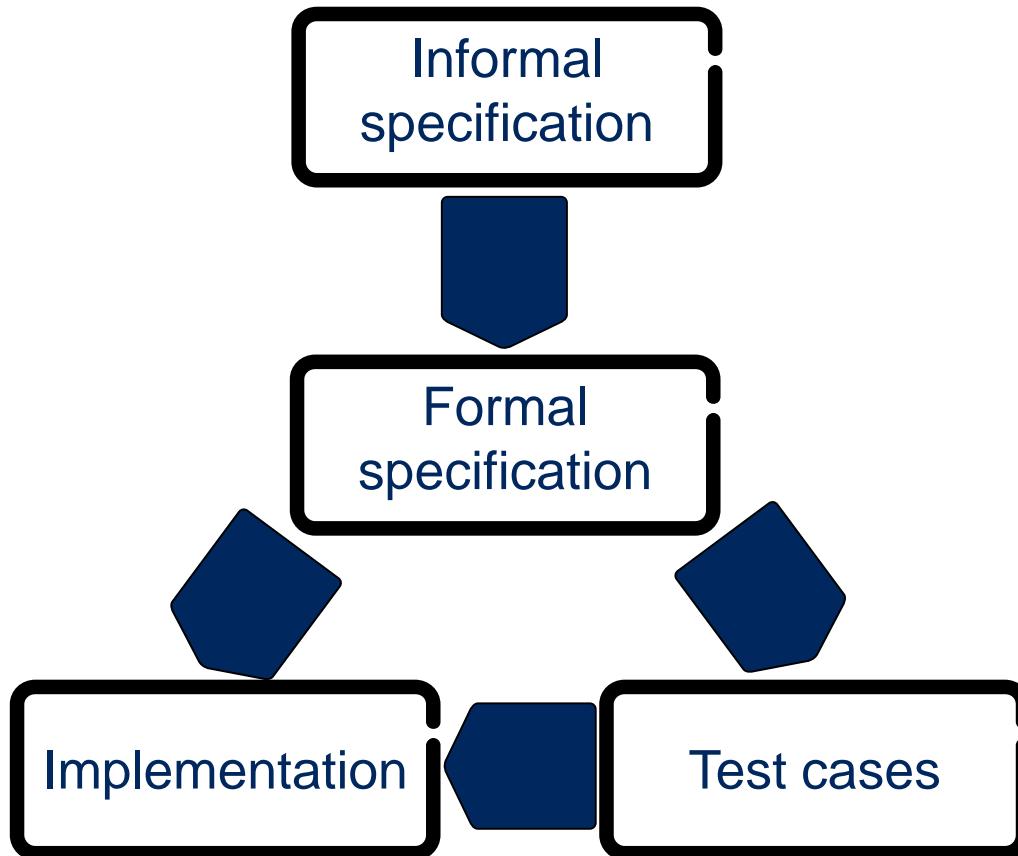
Verdict:

pass,

fail,

inconclusive

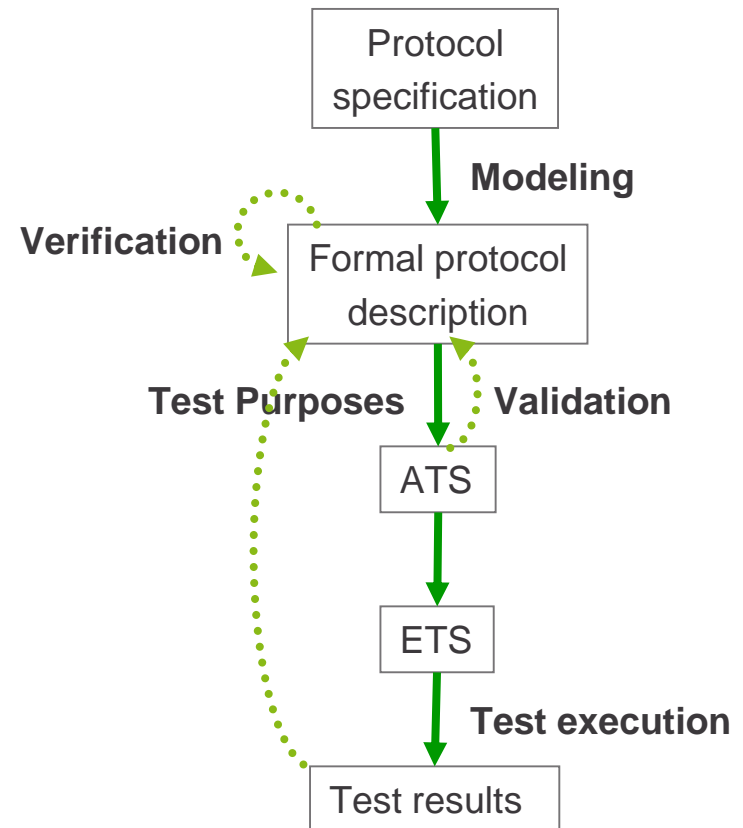
CONFORMANCE TESTING



- › Checks if IUT conforms to its specification
- › Experiments programmed into Test Cases

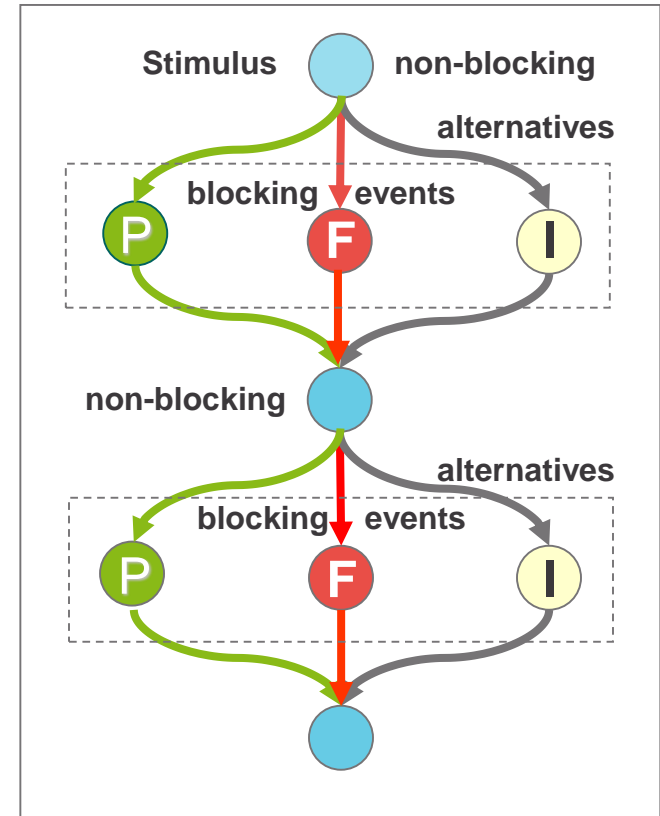
TEST SUITES

- › Verification:
 - Check the correctness of formal model
- › ATS – Abstract Test Suite
 - High-level communication
 - Test for every feature
 - Parameters
- › ETS – Executable Test Suite
 - Coding/Decoding of messages
 - Tests only for implemented features
 - Parameters substituted by concrete values
- › Validation
 - Checks the correctness of ATS



TEST CASES IN BLACK-BOX TEST

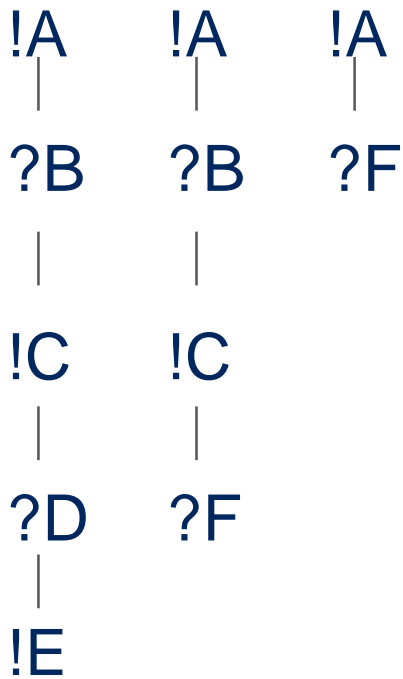
- › Implementation of a Test Purpose
 - TP defines an experiment
- › Focuses on a single requirement
- › Returns verdict (pass, fail, inconclusive)
- › Typically a sequence of action-observation-verdict update:
 - Action (stimulus): non-blocking (e.g. transmit PDU, start timer)
 - Observation (event): takes care of multiple alternative events (e.g. expected PDU, unexpected PDU, timeout)



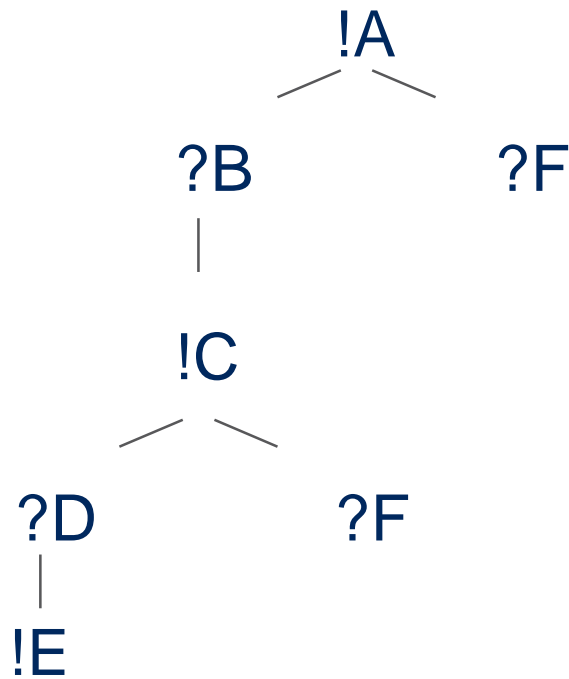
TEST TREE

Possible event

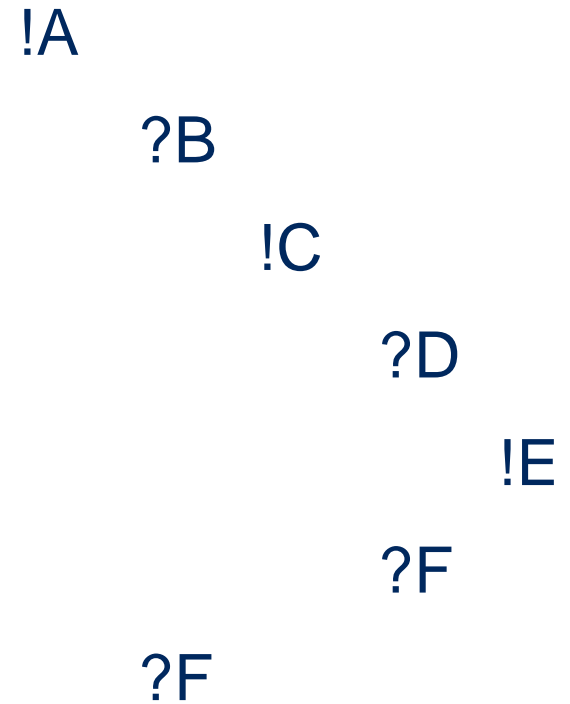
sequences



Behaviour tree



Alternatives

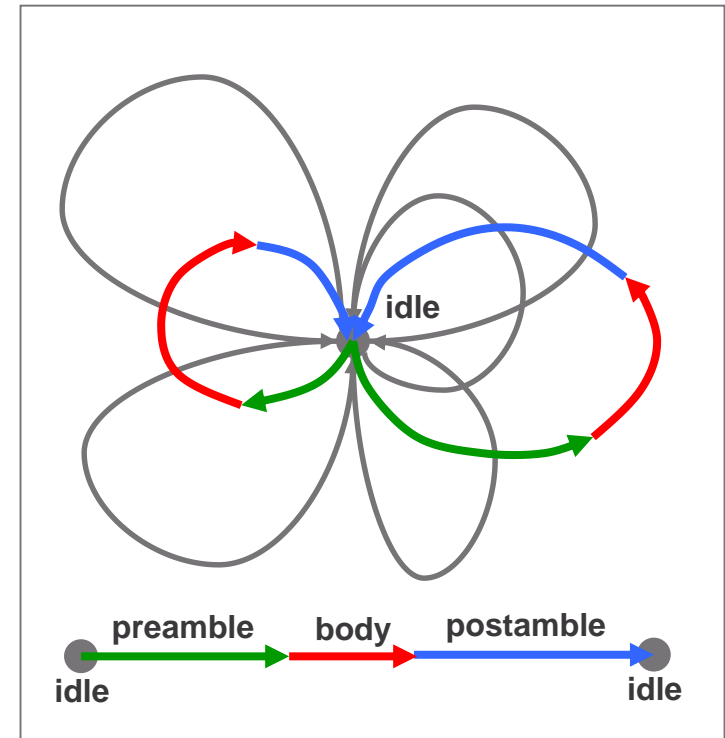


TEST EXECUTION

- › Manual test execution
- › Automated test execution
 - Test scripts
 - Log files

INDEPENDENCE AND STRUCTURE OF ABSTRACT TEST CASES

- › *Abstract test cases* should contain
 - *preamble*: sequence of test events to drive IUT into *initial testing state* from the *starting stable testing state*
 - *test body*: sequence of test events to achieve the *test purpose*
 - *postamble*: sequence of test events which drive IUT into a *finishing stable testing state*
- › Preamble/postamble may be absent



TEST RESULTS

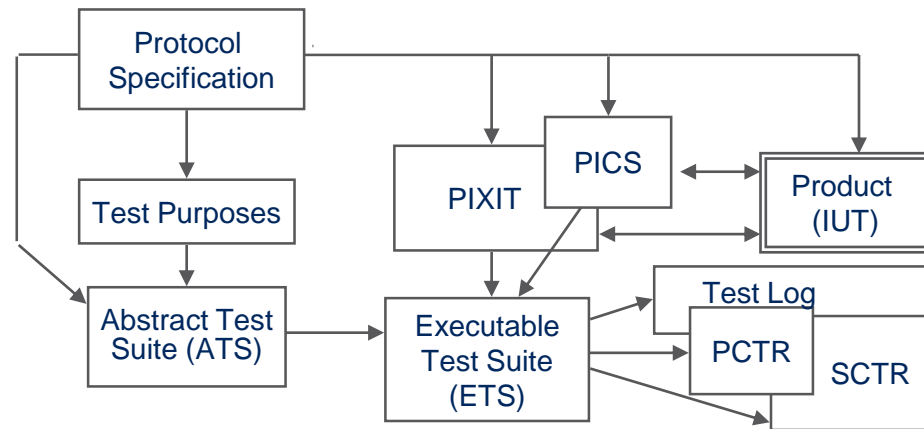
- › Test outcome
 - foreseen
 - unforeseen – test case errors
- › Verdict
 - pass
 - fail
 - inconclusive
- › Test log
- › Requirements on test outcomes
 - repeatable
 - comparable
 - auditable

CONFORMANCE TEST PHASES

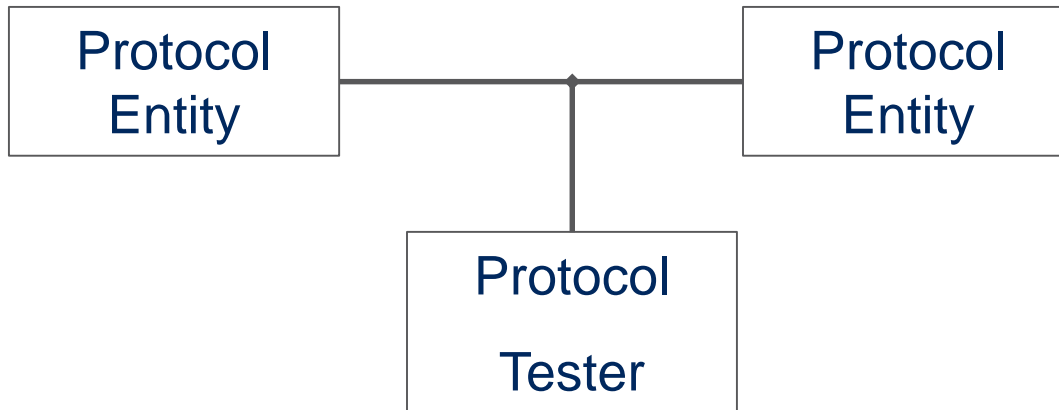
- › Capability Test
 - Static analysis
 - › if protocol options selected correctly
- › Basic Interconnection Test
 - IUT able to communicate at all
- › Behaviour Test
- › Conformance Resolution Test
 - Non standardised methods
 - Multilayer tests
 - Detects reasons of non-conform situations
 - › inconclusive

CONFORMANCE TEST DOCUMENTS

- › PICS: Protocol Implementation Conformance Statement
- › PIXIT: Protocol Implementation eXtra Information on Testing
- › PCTR/SCTR: Protocol/System Conformance Test Report



PASSIVE TESTER



- › Only observes
 - waits for error
 - › no guarantee to happen
- › Protocol Analyzer

ACTIVE TESTER

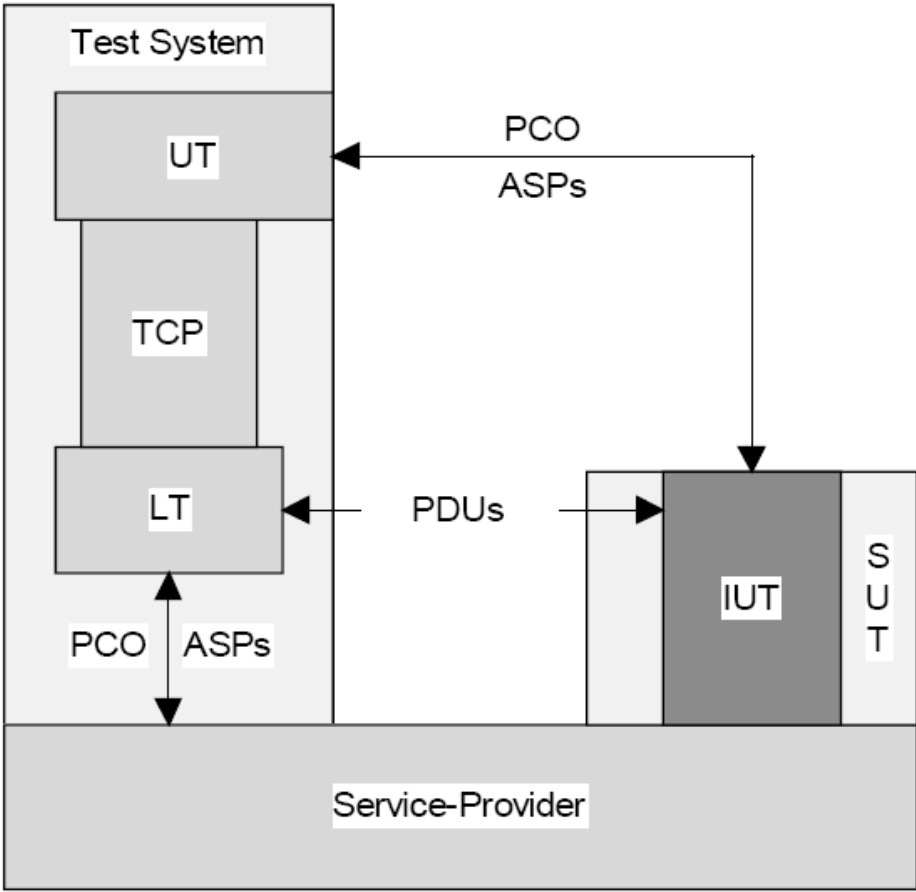


- › Active
 - can send messages
- › Valid testing
- › Provocative testing
 - Invalid
 - › Sends syntactically incorrect messages
 - Improper
 - › Sends syntactically correct messages, but at wrong time/state
- › Test cases are generated before testing starts

TEST ARRANGEMENTS

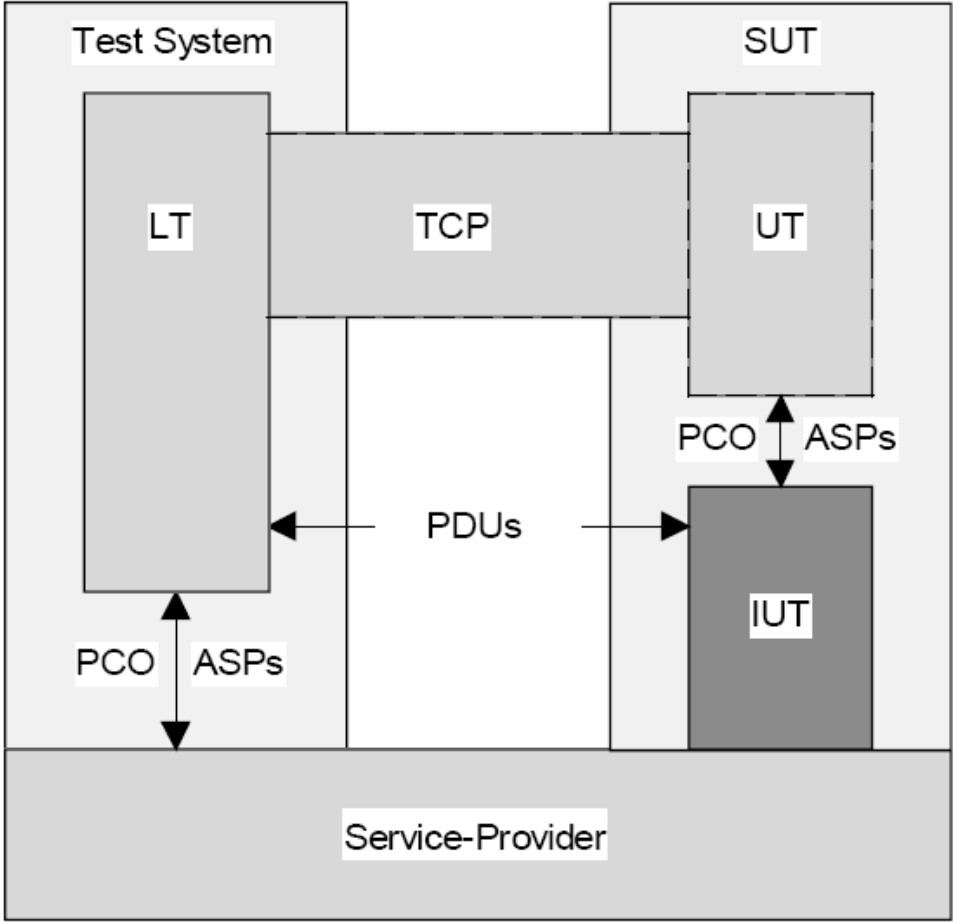
- › ISO 9646
 - › Upper Tester
 - › Lower Tester
- › Local Test Method
- › Distributed Test Method
- › Coordinated Test Method
- › Remote Test Method

LOCAL TEST METHOD



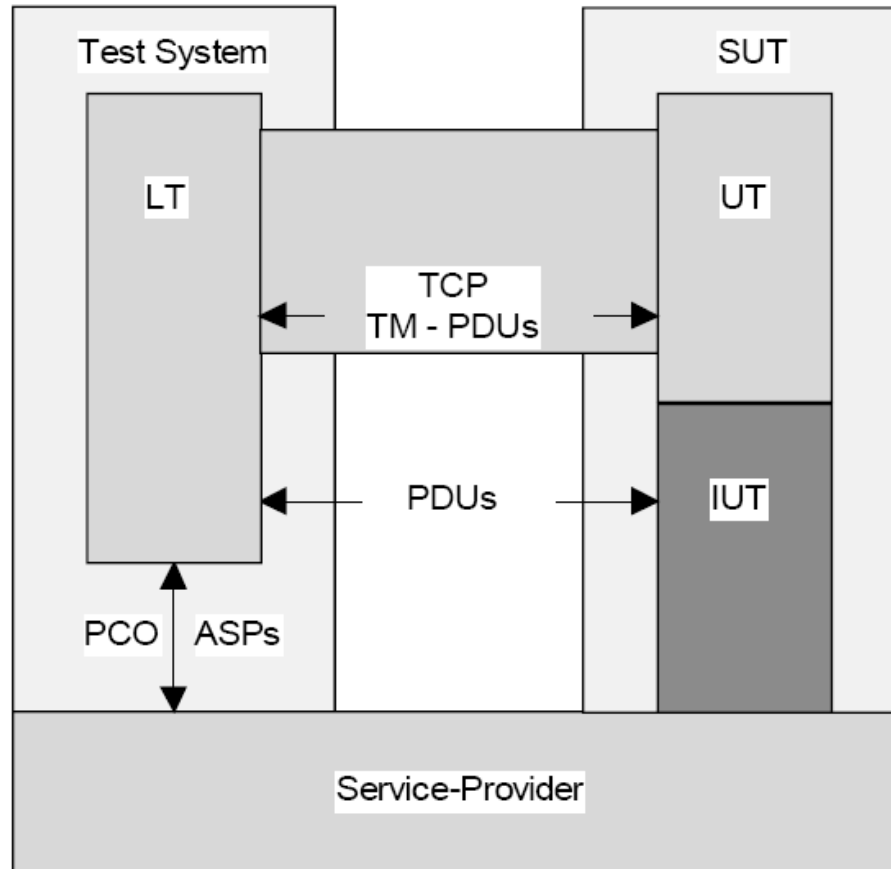
a) The Local test methods

DISTRIBUTED TEST METHOD



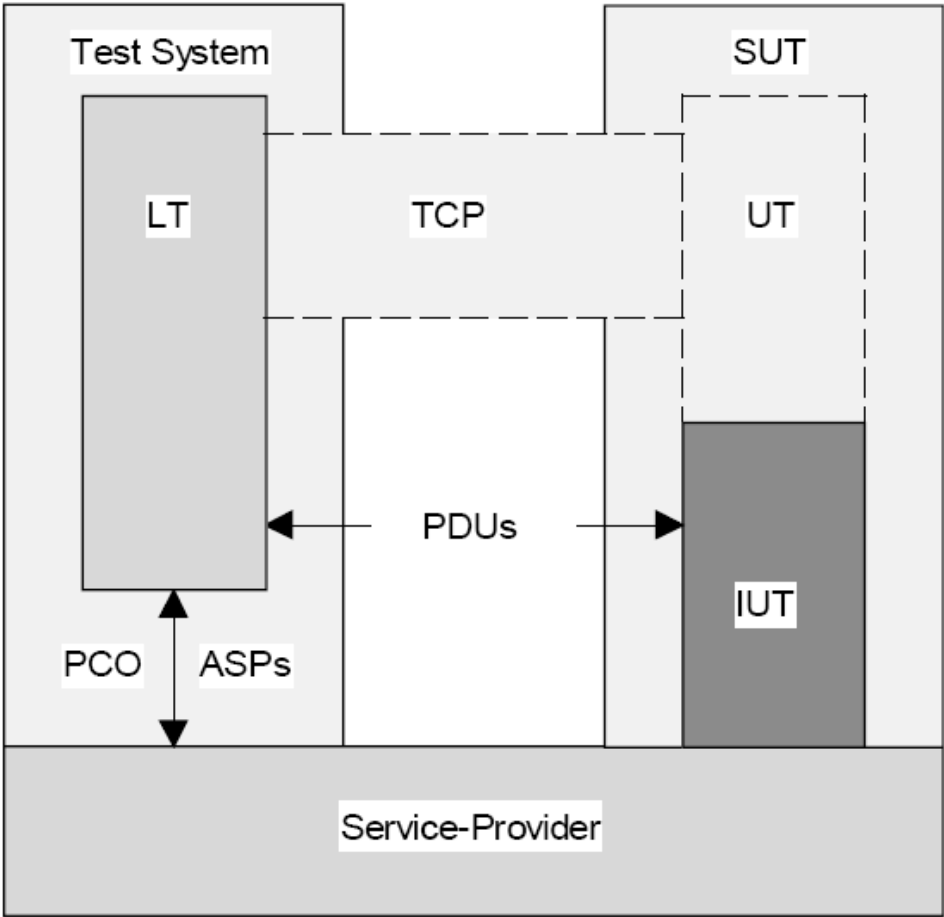
b) The Distributed test methods

COORDINATED TEST METHOD



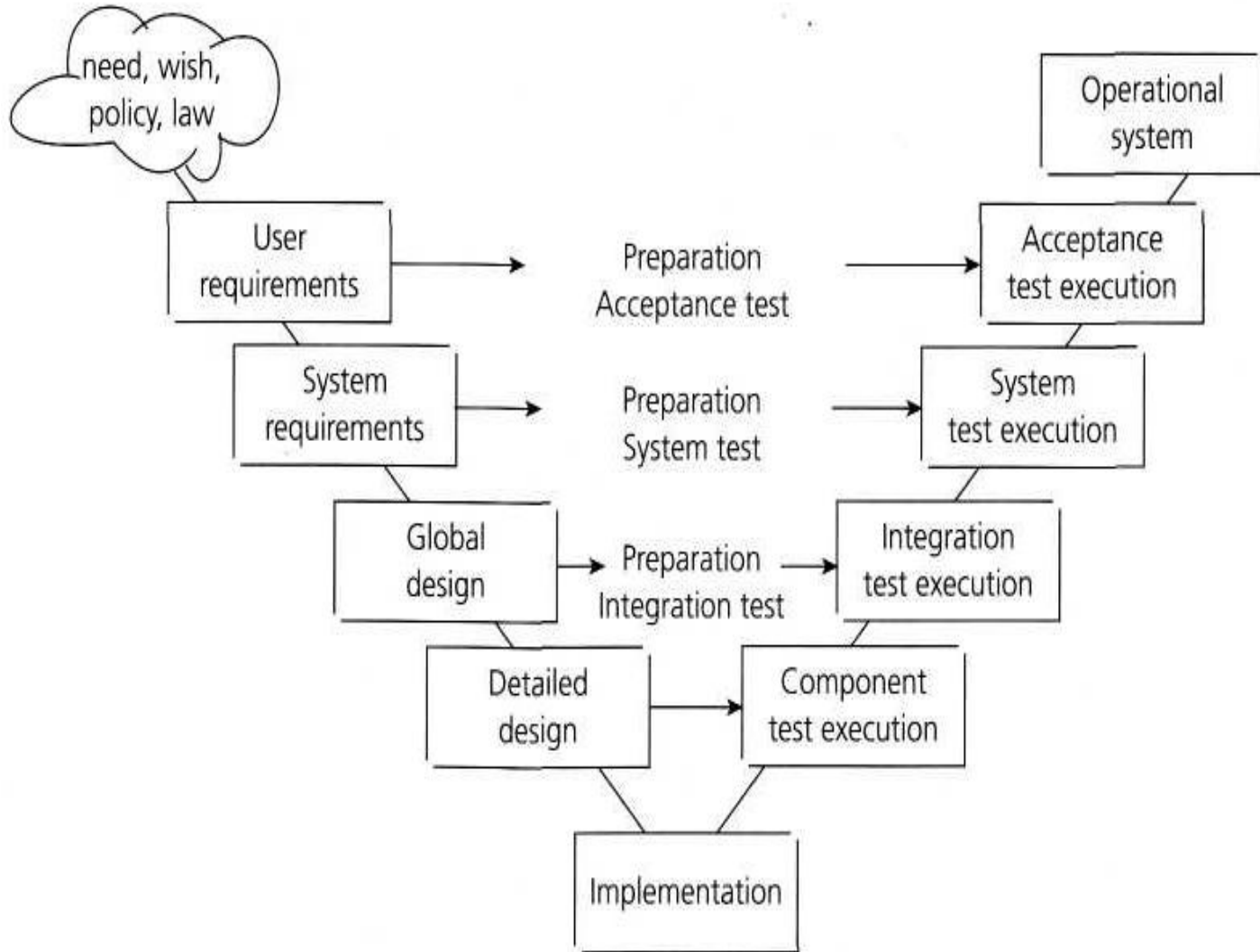
c) The Coordinated test methods

REMOTE TEST METHOD



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d) The Remote test methods



UNIT TEST

- › Unit testing
 - also known as component, module and program testing,
- › Searches for defects in, and verifies the functioning of software that are separately testable
 - e.g. modules, programs, objects, classes, etc.
- › Focuses on one class or method
- › Small, fast
 - Unit tests run fast. If they don't run fast, they aren't unit tests.
 - All the unit tests shall run in less than ~10 seconds

UNIT TEST

- › White-box testing type
 - Access to code
 - Access to development environment
 - Writes the programmer/developer
 - › Sometimes a different one
 - Defects fixed when found

- › They test *how* the code is implemented rather the concept

COMPONENT / UNIT TEST

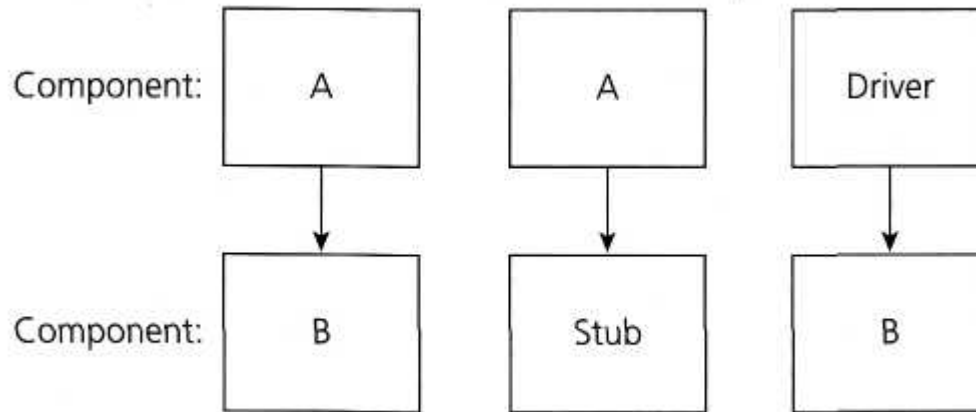
- › All code must have unit tests
- › All code must pass all unit tests before it can be released
- › When a bug is found, tests are created

UNIT TESTS

› Mocking:

- substitutes its own object (the “mock object”) for an object that talks to the outside world
- checks that it is called correctly and provides a pre-scripted response

› Stubs and Drivers



INTEGRATION TESTS

- › **Integration testing** tests interfaces between components, interactions to different parts of a system such as an operating system, file system and hardware or interfaces between systems
- › Checks how code communicates with the rest of world
 - talks to a database
 - communicates across a network
 - touches the file system
 - special things to your environment (such as editing configuration files) to be done to run it
- › Focused integration test
 - **Tests just one interaction**

LEVELS OF INTEGRATION TESTING

- › Component integration testing
 - tests the interactions between software components and is done after component testing;
- › System integration testing
 - tests the interactions between different systems and may be done after system testing.
- › The greater the scope of integration, the more difficult it becomes to isolate failures to a specific interface

INTEGRATION TEST APPROACHES

› 'Big-bang' integration testing

- All components or systems are integrated simultaneously
- Advantage: everything is finished before integration testing starts
 - › no need to simulate (as yet unfinished) parts
- Disadvantage: time-consuming, difficult to trace the cause of failures with this late integration
- Good if expecting to find no problems

› Incremental testing

- All components are integrated one by one, and a test is carried out after each step
- Advantage: defects are found early in a smaller assembly when it is relatively easy to detect the cause.
- Disadvantage: it can be time-consuming since stubs and drivers have to be developed and used in the test

TYPES OF INCREMENTAL INTEGRATION TESTS

- › Top-down: testing takes place from top to bottom, following the control flow or architectural structure (e.g. starting from the GUI or main menu)
 - Components or systems are substituted by stubs.
- › Bottom-up: testing takes place from the bottom of the control flow upwards
 - Components or systems are substituted by drivers
- › Functional incremental: integration and testing takes place on the basis of the functions or functionality, as documented in the functional specification

INTEGRATION TESTS

- › Start with testing high-risk interfaces
 - Prevents major defects at the end of the integration test stage
 - If integration tests are planned before components or systems are built, they can be developed in the order required for most efficient testing
- › Integration tests concentrate solely on the integration itself
 - Checks the communication between the integrated components not the functionality of them
- › Testing of specific non-functional characteristics (e.g. performance) may also be included
- › May be carried out by developers or by testers

INTEGRATION TESTS

- › Shall run in the same way
 - If e.g. a data-base value needed – write it before the test
 - Independent from the order of execution
- › Shall run on its own
 - Set up its environment
 - Restore the previous environment at the end
 - › Even if fails or exception thrown (!)
- › Not needed too many
 - Each shall test just one aspect of the communication
 - Number is proportional to the external interaction types
 - If lot of needed can indicate design problem
 - › Business logic is not well separated from communication

SYSTEM TESTS

- › System testing is concerned with the behavior of the whole system/product
 - It may include tests based on risks and/or requirements specification, business processes, use cases
 - System testing is most often the final test on behalf of development to verify that the system to be delivered meets the specification
 - Purpose: to find as many defects as possible
 - Investigate both **functional** and **non-functional requirements**
 - › Typical non-functional tests include performance and reliability
 - Requires a controlled **test environment**
 - › should correspond to the final target or production environment

ACCEPTANCE TESTS

- › When development organization has performed system test, system will be delivered to the user or customer for **acceptance testing**
 - Acceptance testing is the responsibility of the user or customer
 - The execution of the acceptance test requires a test environment that is representative of the production environment
 - Acceptance testing determines whether the system is fit for its purpose
 - Finding defects should not be the main focus in acceptance testing
 - Although it assesses the system's readiness for deployment and use
 - Not necessarily the final level of testing
 - › large-scale system integration test may come after the acceptance of a system.

TYPES OF ACCEPTANCE TESTING

- › User acceptance test
 - Focuses on the functionality: validates the fitness-for-use of the system by the business user
- › Operational (or production) acceptance test
 - Validates whether the system meets the requirements for operation
 - May include testing of backup/restore, disaster recovery, maintenance tasks and periodic check of security vulnerabilities
- › Contract acceptance testing
 - Contract acceptance testing is performed against a contract's acceptance criteria
 - Acceptance should be formally defined when the contract is agreed
- › Compliance (regulation) acceptance testing
 - Performed against the regulations which must be adhered to, such as governmental, legal or safety regulations

ALPHA/BETA TESTS

- › If the system has been developed for the mass market
 - Feedback is needed from potential or existing users before the software product is put out for sale commercially.
- › Alpha testing
 - Takes place at the developer's site.
 - A cross-section of potential users and members of the developer's organization are invited
 - Developers observe the users and note problems
- › Beta testing
 - A cross-section of users invited, who install it and use it under real-world working conditions.
 - The users send records of incidents with the system to the development organization where the defects are repaired.

END-TO-END TESTS

- › Typically tests use cases
 - Acceptance tests
 - **Functional tests**
- › Touches (almost) all components of the system
 - User interface, business layer, database
- › Slow
 - Labor intensive setup, configuration, teardown
 - Tend to break when the system/labor configuration changes
 - Tests a lot of branches in code – but what exactly?
 - Run seldom – at releasing

TEST TYPES: THE TARGETS OF TESTING

- › A **test type** is focused on a particular test objective
 - testing of a function to be performed by the component or system;
 - a nonfunctional quality characteristic, such as reliability or usability;
 - the structure/architecture of the component or system;
 - related to changes,
 - › i.e. confirming that defects have been fixed (confirmation testing, or re-testing)
 - › looking for unintended changes (regression testing).
- › Depending on its objectives, testing will be organized differently
 - E.g component testing aimed at performance would be quite different to component testing aimed at achieving decision coverage.

FUNCTIONAL TESTING

- › The function of a system (or component) is
 - 'what it does'.
 - Typically described in a requirements specification, a functional specification, or in use cases
- › **Functional testing** considers the specified behavior
 - Black-box testing
 - Based upon ISO 9126
 - Can focus on suitability, interoperability, security, accuracy and compliance

VERSIONS OF FUNCTION TESTING

› Requirements-based testing

- Uses a specification of the functional requirements
- A good way to start is to use the table of contents of the requirements specification
- Decide what to test (or not to test)
- Prioritize the requirements based on risk criteria
 - › This ensures that the most important/critical tests are included

› Business-process-based testing

- Uses knowledge of the business processes
- E.g business processes of a personnel and payroll system can be:
 - › someone joins the company,
 - › is paid on a regular basis
 - › leaves the company, etc.

NON-FUNCTIONAL TESTING

- › Testing of product quality characteristics or non-functional attributes of the system
 - how well or how fast the system works
 - › performance testing (different load)
 - › load testing (expected load)
 - › stress testing (overloading)
 - › usability testing
 - › maintainability testing
 - › reliability testing
 - › portability testing

LOAD TEST

- › Test how the system behaves in real environment
 - Expected traffic
- › Testing with (high) traffic
 - Different traffic models
 - Simulating a lot of users
 - Need automation
 - Time limits
 - › Off-line, on-line
- › Very expensive tools

QUALITY CHARACTERISTICS

ISO 9126

- › **Functionality** (Functional testing)

 - suitability, accuracy, security, interoperability;

- › **Reliability**

 - Maturity (robustness), fault-tolerance, recoverability

- › **Usability**

 - understandability, learnability, operability, attractiveness

- › **Efficiency**

 - time behavior (performance), resource utilization

- › **Maintainability**

 - analyzability, changeability, stability, testability

- › **Portability**

 - adaptability, installability, co-existence, replaceability

TESTING RELATED TO CHANGES - 1

- › Re-testing (Confirmation testing)
 - Test fails -> determine the cause -> defect is reported -> new version of the software in which defect fixed
 - Execute the failed test again to confirm that the defect has indeed been fixed
- › Important to ensure that the test is executed in exactly the same way as it was the first time using the same
 - Inputs
 - Data
 - Environment

TESTING RELATED TO CHANGES - 2

- › Regression testing
 - Check if the modification of software/environment do not introduce bug in the non-modified part
- › Also executes test cases that have been executed before
 - for regression testing, the test cases probably passed the last time they were executed
 - but in confirmation testing - they failed the last time
- › Designed to collectively exercise most functions

REGRESSION TESTS – CTD.

- › All the regression tests shall be executed every time a new version of software is produced
 - After bug-fixes
 - Change existing functionality
 - Introduce new functionality
 - Environment changes
 - › E.g. new Data-base, new compiler
- › Ideal candidates for **automation**

EVOLUTION OF REGRESSION TEST SUITE

- › Maintenance of a regression test suite is necessary
 - Shall evolve in line with the software
- › When new functionality is added to a system
 - New regression tests should be added
- › If old functionality is changed or removed
 - Regression tests be changed or removed
- › If becomes too large
 - Subset of the test cases has to be chosen
 - Keep the new/recently failed tests
 - Eliminate test cases that have not found a defect for a long time (though this approach should be used with some care!)