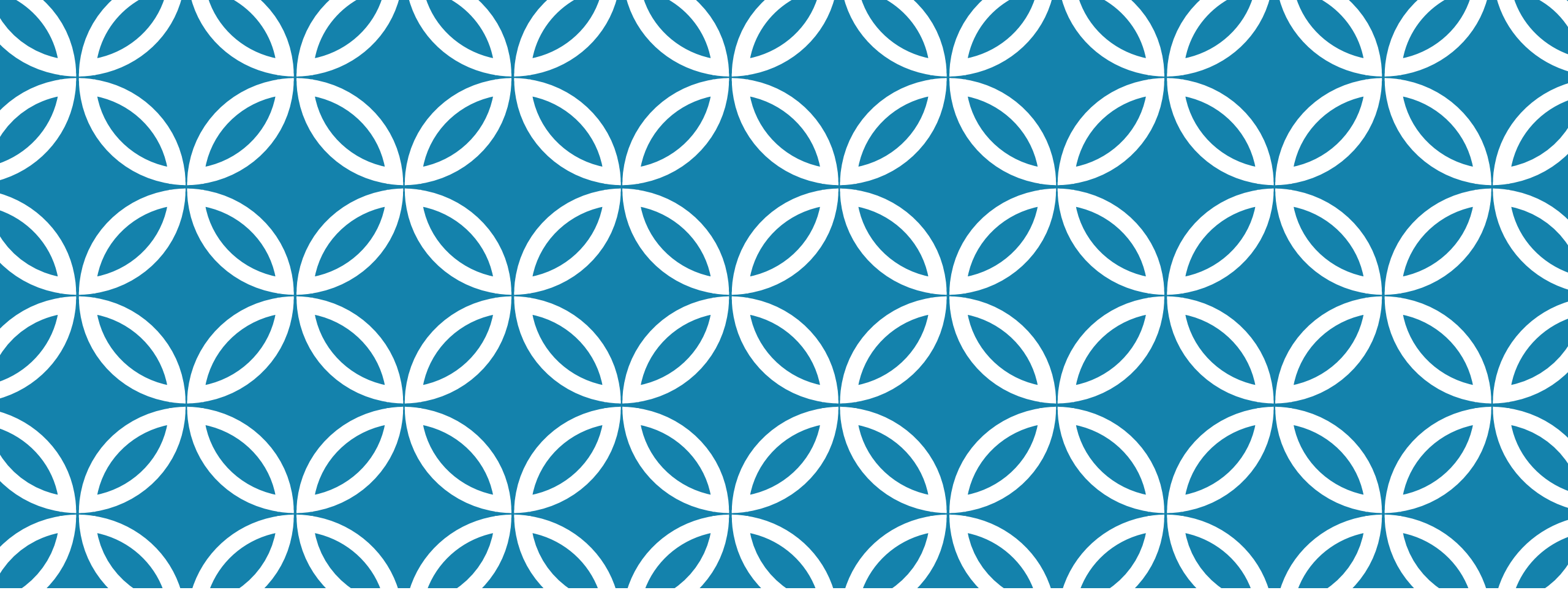


CHAPTER – 8
SYSTEM TEST CATEGORIES

OUTLINE OF THE CHAPTER

- Taxonomy of System Tests
- Basic Tests
- Functionality Tests
- Robustness Tests
- Interoperability Tests
- Performance Tests
- Scalability Tests
- Stress Tests
- Load and Stability Tests
- Regression Tests
- Documentation Tests
- Regulatory Tests

TAXONOMY OF SYSTEM TESTS

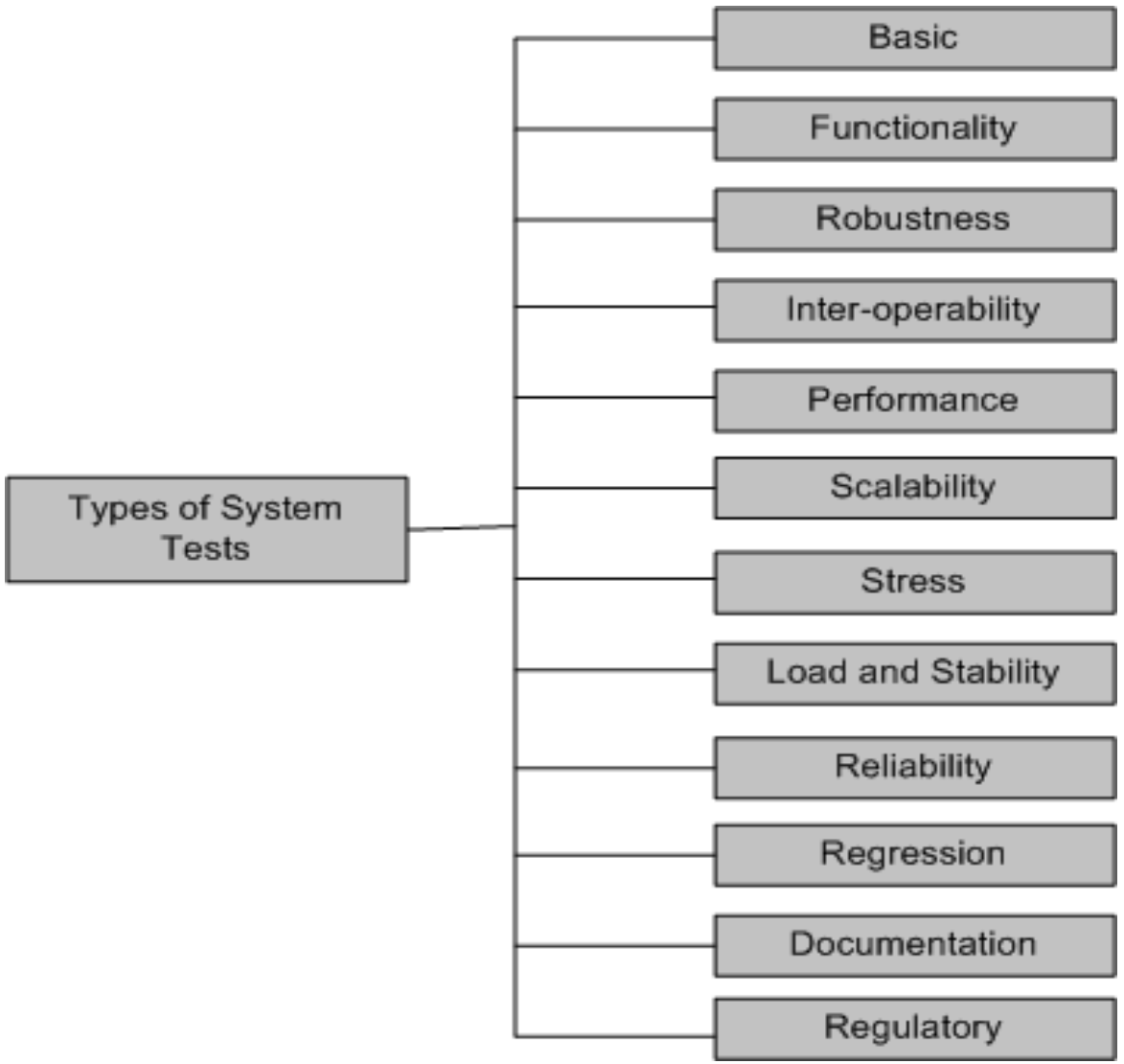


Figure 8.1: Types of system tests

TAXONOMY OF SYSTEM TESTS

- **Basic tests** provide an evidence that the system can be installed, configured and be brought to an operational state
- **Functionality tests** provide comprehensive testing over the full range of the requirements, within the capabilities of the system
- **Robustness tests** determine how well the system recovers from various input errors and other failure situations
- **Inter-operability tests** determine whether the system can inter-operate with other third party products
- **Performance tests** measure the performance characteristics of the system, e.g., throughput and response time, under various conditions

TAXONOMY OF SYSTEM TESTS

- **Scalability tests** determine the scaling limits of the system, in terms of user scaling, geographic scaling, and resource scaling
- **Stress tests** put a system under stress in order to determine the limitations of a system and, when it fails, to determine the manner in which the failure occurs
- **Load and Stability** tests provide evidence that the system remains stable for a long period of time under full load
- **Reliability tests** measure the ability of the system to keep operating for a long time without developing failures
- **Regression tests** determine that the system remains stable as it cycles through the integration of other subsystems and through maintenance tasks
- **Documentation tests** ensure that the system's user guides are accurate and usable

BASIC TESTS

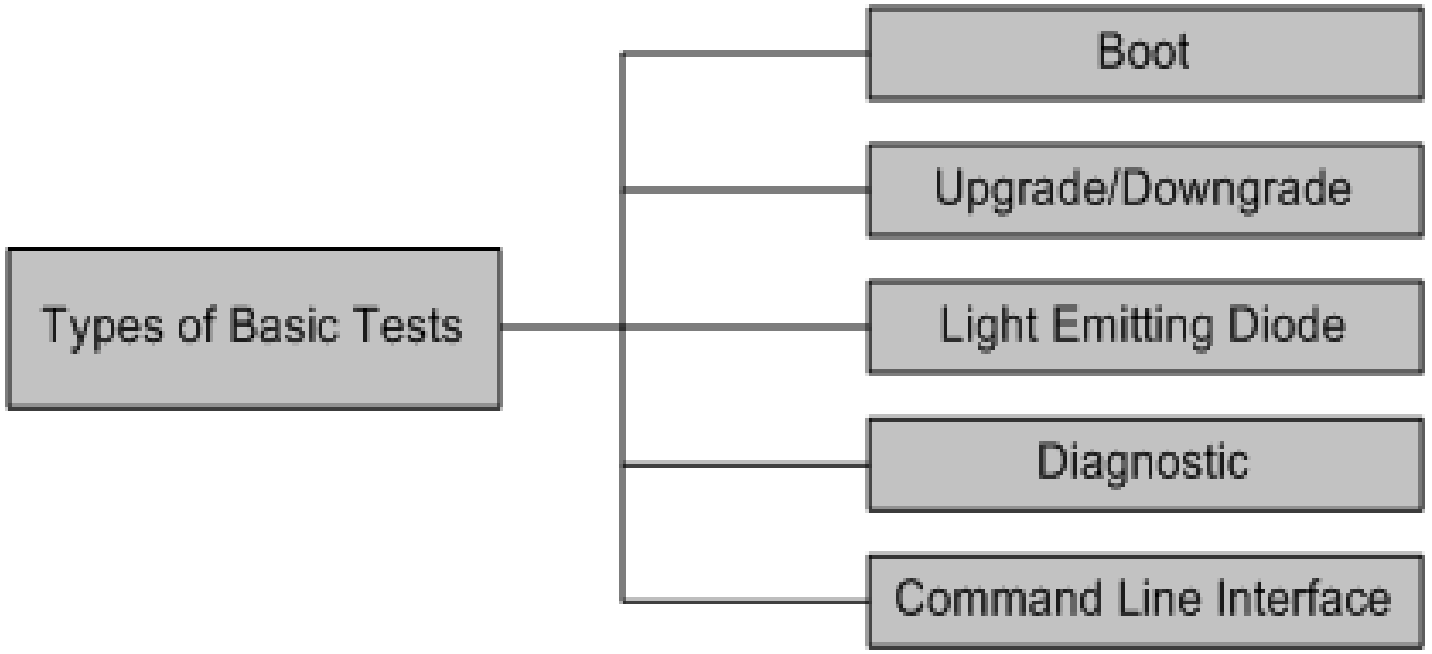


Figure 8.2: Types of basic tests

Boot: Boot tests are designed to verify that the system can boot up its software image (or, build) from the supported boot options

Upgrade/Downgrade: Upgrade/downgrade tests are designed to verify that the system software can be upgraded or downgraded (rollback) in a graceful manner

BASIC TESTS

Light Emitting Diode: The LED (Light Emitting Diode) tests are designed to verify that the system LED status indicators functioning as desired

Diagnostic: Diagnostic tests are designed to verify that the hardware components (or, modules) of the system are functioning as desired

- **Power-On Self Test**
- **Ethernet Loop Back Test**
- **Bit Error Test**

Command line Interface: Command Line Interface (CLI) tests are designed to verify that the system can be configured

FUNCTIONALITY TESTS

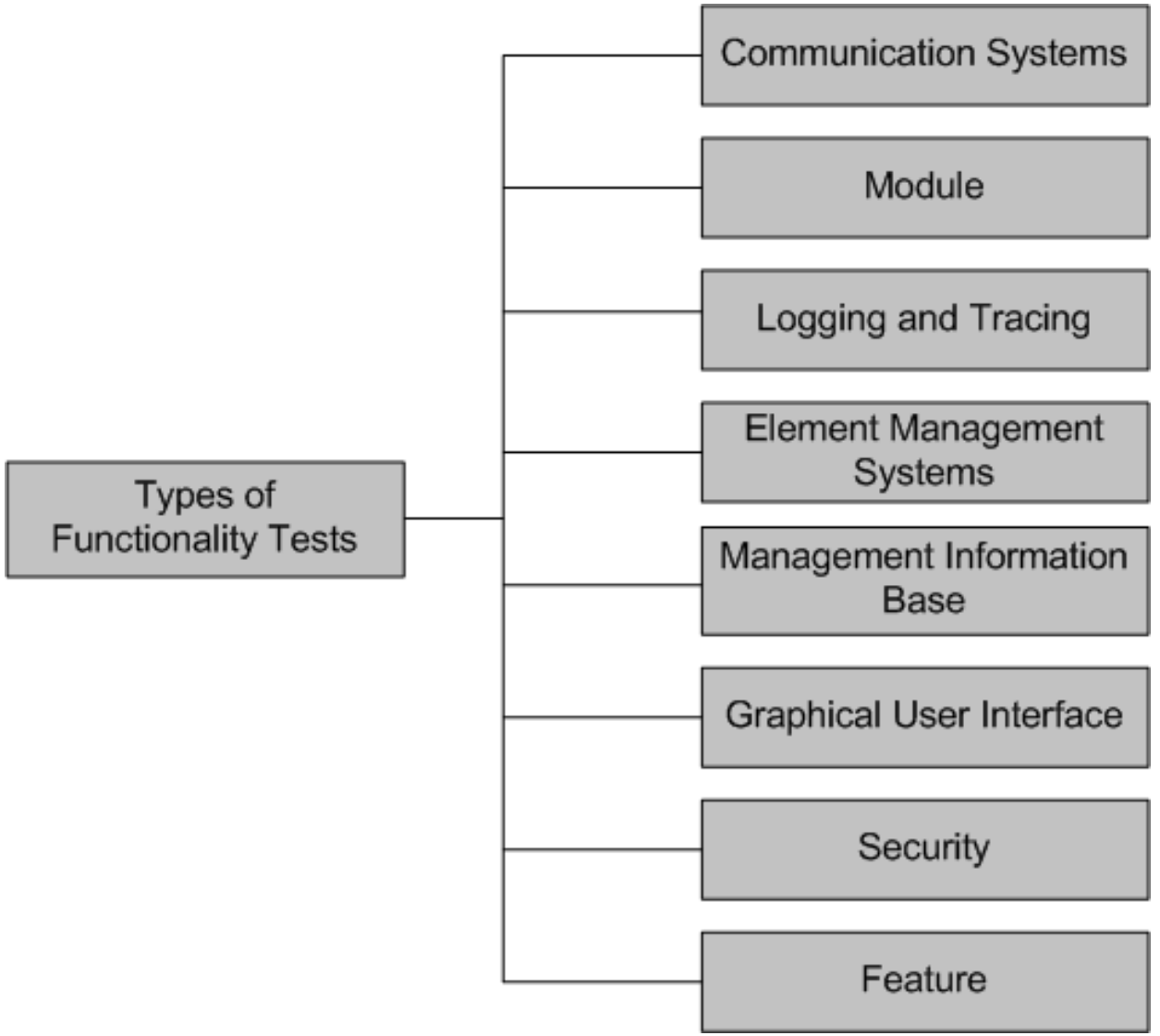


Figure 8.3: Types of functionality tests

FUNCTIONALITY TESTS

Communication Systems Tests

- These tests are designed to verify the implementation of the communication systems as specified in the customer requirements specification
- Four types of communication systems tests are recommended
  - Basis interconnection tests
  - Capability tests
  - Behavior tests
  - System resolution tests

Module Tests

- Module Tests are designed to verify that all the modules function individually as desired within the systems
- The idea here is to ensure that individual modules function correctly within the whole system.
  - For example, an Internet router contains modules such as line cards, system controller, power supply, and fan tray. Tests are designed to verify each of the functionalities

FUNCTIONALITY TESTS

Logging and Tracing Tests

- Logging and Tracing Tests are designed to verify the configurations and operations of logging and tracing
- This also includes verification of “flight data recorder: non-volatile Flash memory” logs when the system crashes

Element Management Systems (EMS) Tests

- EMS tests verifies the main functionalities, which are to manage, monitor and upgrade the communication systems network elements
- It includes both EMS client and EMS servers functionalities

Management Information Base (MIB) Tests

- MIB tests are designed to verify
  - Standard MIBs including MIB II
  - Enterprise MIBs specific to the system

FUNCTIONALITY TESTS

Graphical User Interface Tests

- Tests are designed to look-and-feel the interface to the users of an application system
- Tests are designed to verify different components such as icons, menu bars, dialog boxes, scroll bars, list boxes, and radio buttons
- The GUI can be utilized to test the functionality behind the interface, such as accurate response to database queries
- Tests the usefulness of the on-line help, error messages, tutorials, and user manuals
- The usability characteristics of the GUI is tested, which includes the following
  - ***Accessibility:*** Can users enter, navigate, and exit with relative ease?
  - ***Responsiveness:*** Can users do what they want and when they want in a way that is clear?
  - ***Efficiency:*** Can users do what they want to with minimum number of steps and time?
  - ***Comprehensibility:*** Do users understand the product structure with a minimum amount of effort?

FUNCTIONALITY TESTS

Security Tests

- Security tests are designed to verify that the system meets the security requirements
  - Confidentiality
    - It is the requirement that data and the processes be protected from unauthorized disclosure
  - Integrity
    - It is the requirement that data and process be protected from unauthorized modification
  - Availability
    - It is the requirement that data and processes be protected form the denial of service to authorized users
- Security test scenarios should include negative scenarios such as misuse and abuse of the software system

FUNCTIONALITY TESTS

Security Tests (cont'd) : useful types of security tests includes the following:

- Verify that only authorized accesses to the system are permitted
- Verify the correctness of both encryption and decryption algorithms for systems where data/messages are encoded.
- Verify that illegal reading of files, to which the perpetrator is not authorized, is not allowed
- Ensure that virus checkers prevent or curtail entry of viruses into the system
- Ensure that the system is available to authorized users when a zero-day attack occurs
- Try to identify any "backdoors" in the system usually left open by the software developers

FUNCTIONALITY TESTS

Feature Tests

- These tests are designed to verify any additional functionalities which are defined in requirement specification but not covered in the functional category discussed
- Examples
  - Data conversion testing
  - Cross-functionality testing

ROBUSTNESS TESTS

Robustness means how much sensitive a system is to erroneous input and changes its operational environment

Tests in this category are designed to verify how gracefully the system behaves in error situations and ina a changed operational environment

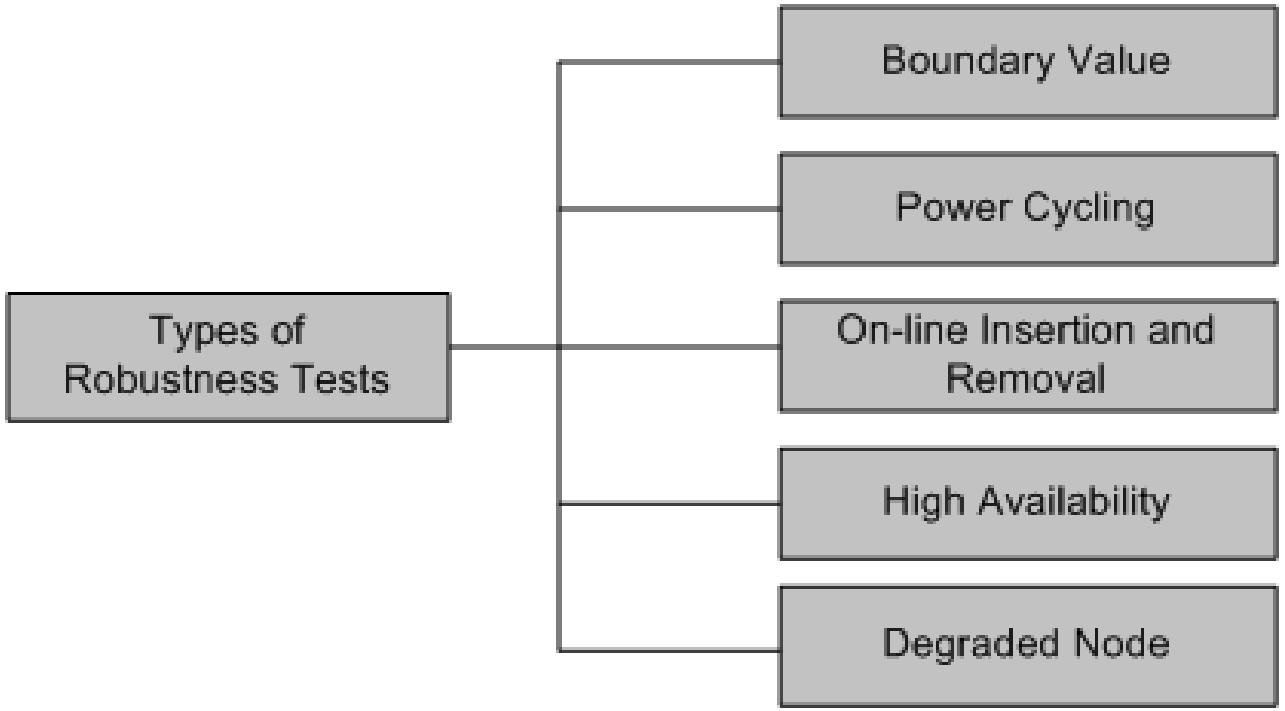


Figure 8.4: Types of robustness tests

ROBUSTNESS TESTS

Boundary value

- Boundary value tests are designed to cover boundary conditions, special values, and system defaults
- The tests include providing invalid input data to the system and observing how the system reacts to the invalid input.

Power cycling

- Power cycling tests are executed to ensure that, when there is a power glitch in a deployment environment, the system can recover from the glitch to be back in normal operation after power is restored

On-line insertion and removal

- On-line Insertion and Removal (OIR) tests are designed to ensure that on-line insertion and removal of modules, incurred during both idle and heavy load operations, are gracefully handled and recovered

ROBUSTNESS TESTS

High Availability

- The concept of high availability is also known as **fault tolerance**
- High availability tests are designed to verify the redundancy of individual modules, including the software that controls these modules.
- The goal is to verify that the system gracefully and quickly recovers from hardware and software failures without adversely impacting the operation of the system
- High availability is realized by means of proactive methods to maximize service up-time, and to minimize the downtime

Degraded Node

- Degraded node (also known as failure containment) tests verify the operation of a system after a portion of the system becomes non-operational
- It is a useful test for all mission-critical applications.

INTEROPERABILITY TESTS

Tests are designed to verify the ability of the system to inter-operate with third party products

The re-configuration activities during interoperability tests is known as configuration testing

Another kind of inter-operability tests is called (backward) compatibility tests

- Compatibility tests verify that the system works the same way across different platforms, operating systems, data base management systems
- Backward compatibility tests verify that the current software build flawlessly works with older version of platforms

PERFORMANCE TESTS

Tests are designed to determine the performance of the actual system compared to the expected one

Tests are designed to verify response time, execution time, throughput, resource utilization and traffic rate

One needs to be clear about the specific data to be captured in order to evaluate performance metrics.

For example, if the objective is to evaluate the response time, then one needs to capture

- End-to-end response time (as seen by external user)
- CPU time
- Network connection time
- Database access time
- Network connection time
- Waiting time

SCALABILITY TESTS

Tests are designed to verify that the system can scale up to its engineering limits

Scaling tests are conducted to ensure that the system response time remains the same, or increases by a small amount, as the number of users are increased.

There are three major causes of these limitations:

- data storage limitations
- network bandwidth limitations
- speed limit

Extrapolation is often used to predict the limit of scalability

STRESS TESTS

The goal of stress testing is to evaluate and determine the behavior of a software component while the offered load is in excess of its designed capacity

The system is deliberately stressed by pushing it to and beyond its specified limits

It ensures that the system can perform acceptably under worst-case conditions, under an expected peak load. If the limit is exceeded and the system does fail, then the recovery mechanism should be invoked

Stress tests are targeted to bring out the problems associated with one or more of the following:

- Memory leak
- Buffer allocation and memory carving

LOAD AND STABILITY TESTS

Tests are designed to ensure that the system remains stable for a long period of time under full load

When a large number of users are introduced and applications that run for months without restarting, a number of problems are likely to occur:

- the system slows down
- the system encounters functionality problems
- the system crashes altogether

Load and stability testing typically involves exercising the system with virtual users and measuring the performance to verify whether the system can support the anticipated load

This kind of testing help one to understand the ways the system will fare in real-life situations

RELIABILITY TESTS

Reliability tests are designed to measure the ability of the system to remain operational for long periods of time.

The reliability of a system is typically expressed in terms of mean time to failure (MTTF)

The average of all the time intervals between successive failures is called the MTTF

After a failure is observed, the developers analyze and fix the defects, which consumes some time – let us call this interval the repair time.

The average of all the repair times is known as the mean time to repair (MTTR)

Now we can calculate a value called mean time between failure (MTBF) as MTBF = MTTF + MTTR

The random testing technique discussed in Chapter 9 is used for reliability measurement

The software reliability modeling and testing is discussed in Chapter 15 in detail

REGRESSION TESTS

In this category, new tests are not designed, instead, test cases are selected from the existing pool and executed

The main idea in regression testing is to verify that no defect has been introduced into the unchanged portion of a system due to changes made elsewhere in the system

During system testing, many defects are revealed and the code is modified to fix those defects

One of four different scenarios can occur for each fix:

- The reported defect is fixed
- The reported defect could not be fixed inspite of making an effort
- The reported defect has been fixed, but something that used to work before has been failing
- The reported defect could not be fixed inspite of an effort, and something that used to work before has been failing

REGRESSION TESTS

One possibility is to re-execute every test case from version n − 1 to version n before testing anything new

A full test of a system may be prohibitively expensive.

A subset of the test cases is carefully selected from the existing test suite to

- maximize the likelihood of uncovering new defects
- reduce the cost of testing

DOCUMENTATION TESTS

Documentation testing means verifying the technical accuracy and readability of the user manuals, tutorials and the on-line help

Documentation testing is performed at three levels:

- ***Read test:*** In this test a documentation is reviewed for clarity, organization, flow, and accuracy without executing the documented instructions on the system
- ***Hands-on test:*** Exercise the on-line help and verify the error messages to evaluate their accuracy and usefulness.
- ***Functional test:*** Follow the instructions embodied in the documentation to verify that the system works as it has been documented.

REGULATORY TESTS

- In this category, the final system is shipped to the regulatory bodies in those countries where the product is expected to be marketed
- The idea is to obtain compliance marks on the product from various countries
- Most of these regulatory bodies issue safety and EMC (electromagnetic compatibility)/ EMI (electromagnetic interference) compliance certificates (emission and immunity)
- The regulatory agencies are interested in identifying flaws in software that have potential safety consequences
- The safety requirements are primarily based on their own published standards

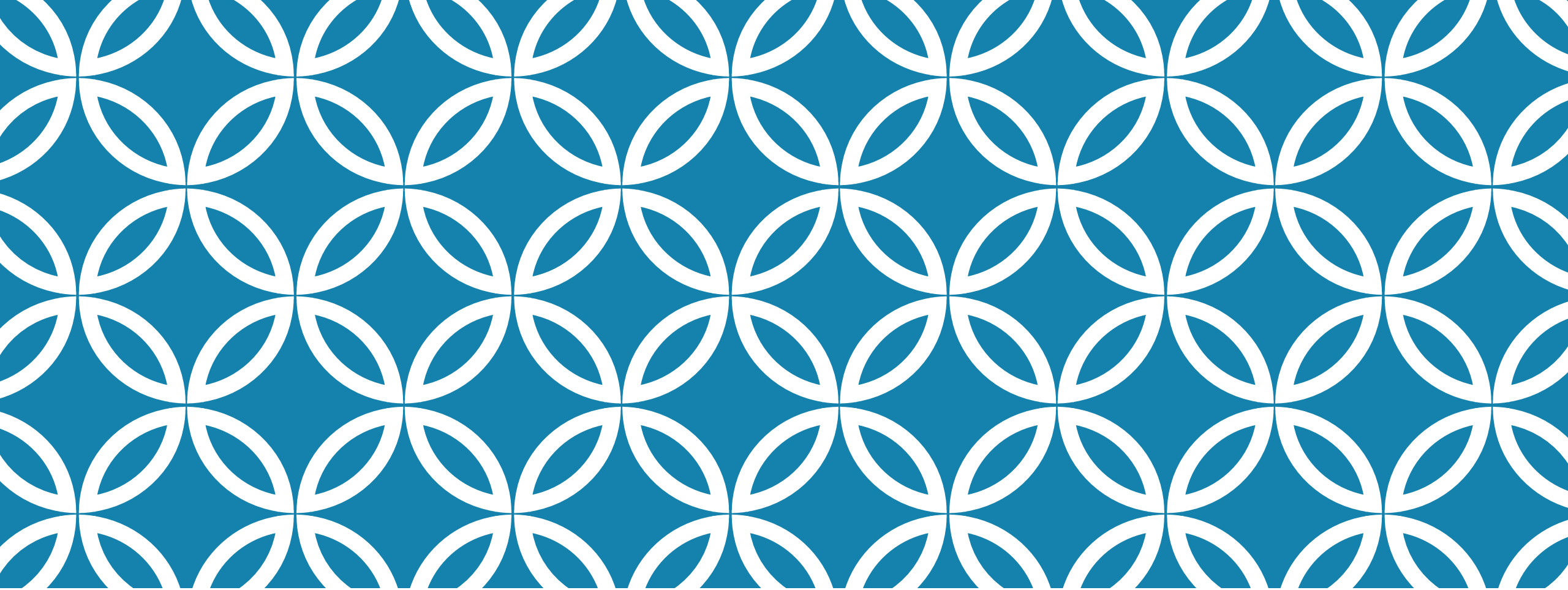
SOFTWARE SAFETY

- A *hazard* is a state of a system or a physical situation which when combined with certain environmental conditions, could lead to an *accident* or *mishap*
- An *accident* or *mishap* is an unintended event or series of events that results in death, injury, illness, damage or loss of property, or harm to the environment
- Software *safety* is defined in terms of hazards
- A software in isolation cannot do physical damage. However, a software in the context of a system and an embedding environment could be vulnerable
- Examples:
  - A software module in a database application is not hazardous by itself, but when it is embedded in a missile navigation system, it could be hazardous
  - If a missile takes a U-turn because of a software error in the navigation system, and destroys the submarine that launched it, then it is not a safe software

SAFETY ASSURANCE

There are two basic tasks performed by a **safety assurance** engineering team:

- Provide methods for identifying, tracking, evaluating, and eliminating hazards associated with a system
- Ensure that safety is embedded into the design and implementation in a timely and cost-effective manner, such that the risk created by the user/operator error is minimized



THANK YOU!!