5. 5G Mobile Communication System Test and Verification Guide

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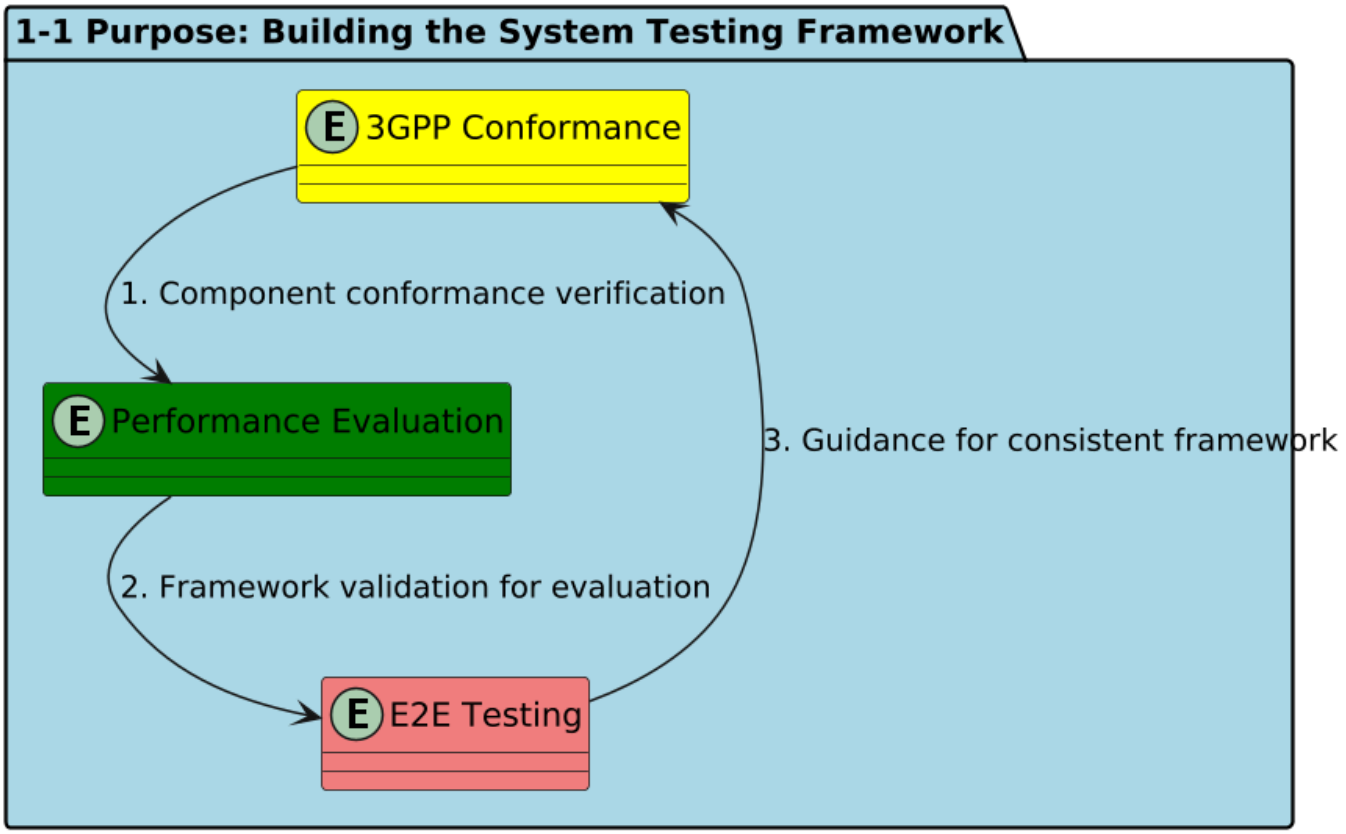
Chapter 1: Introduction

1.1 Purpose

This guide provides a framework for conducting system and component testing of the 5G Mobile Communication System (5G MCS). It aims to standardize the authentication process for 5G networks and enable engineers to effectively verify the following key aspects:

- Building a framework for conformance verification of systems based on 3GPP specifications
- Evaluating the quality and performance of individual components
- Establishing methodologies to support end-to-end testing between UE, gNB, and 5GC

Chapter 1.1: Framework for System and Component Testing



1.2 Scope of Application

This guide applies to the following targets:

5G MCS Components:

- The entire 5G MCS, including UE, gNB, and 5GC.

Test Levels:

- Unit Testing
- Integration Testing
- System-Level Testing
- End-to-End (E2E) Testing

Test Categories:

- Conformance Testing (Verification of compliance with 3GPP standards)
- Performance Testing (Throughput, latency, and reliability evaluation)
- Resilience Testing (Fault scenario validation)

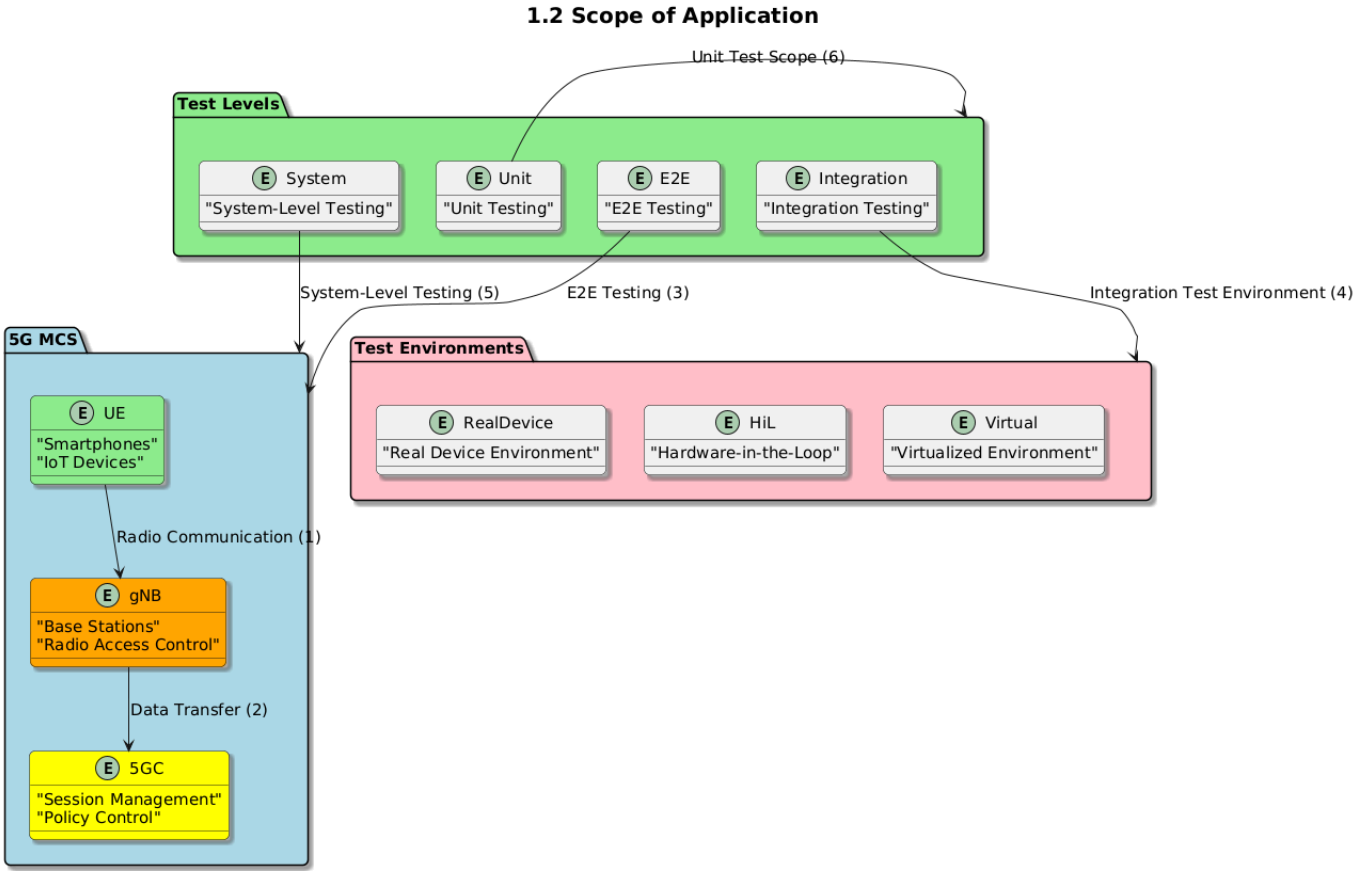
Test Environments:

- Real device environment
- Virtualized environment (NFV/cloud-based)
- Hardware-in-the-loop (HiL)

Target Scenarios:

- eMBB (enhanced Mobile Broadband)
- URLLC (Ultra-Reliable Low Latency Communications)
- mMTC (massive Machine-Type Communications)

The following diagram illustrates the scope of application:



Chapter 2: Overview of Testing

2.1 Definitions of Test Categories

Conformance Testing:
Purpose: To verify the compliance of each component and the entire system with 3GPP specifications.
Main focus areas: RRC, NAS, PDCP, RLC, PHY layers.
Tools used: TTCN-3, Protocol Conformance Tester (PCT).
Performance Testing:
Purpose: To evaluate the throughput, latency, and reliability of the system and its components.
Key metrics: Data throughput, end-to-end latency, packet loss rate.
Tools used: iPerf, Open5GS, Network Simulator (NS-3).
End-to-End (E2E) Testing:
Purpose: To assess the overall functional integrity of the system and verify interoperability among components.
Main focus areas: URLLC, eMBB, mMTC scenarios.
Tools used: Spirent, Keysight.

1. Reason SDAP is Not Explicitly Described in Test Categories
Although SDAP plays a critical role in 5G QoS management and is located above the PDCP layer as part of the RAN, it is often not explicitly listed in standard test category descriptions due to the following reasons:

- The test focus is distributed across the entire protocol stack.
- In conformance testing, the RAN protocol stack (PHY, MAC, RLC, PDCP, etc.) is typically tested comprehensively. SDAP is implicitly included within the testing of PDCP and RLC layers.
- SDAP is rarely treated as an independent test object. It functions in coordination with other layers to handle QoS flows and therefore is generally evaluated as part of the broader QoS mechanism rather than in isolation.
- When SDAP is implicitly addressed in test cases, the following performance metrics are usually the main focus:
    - Accurate QoS flow mapping
    - Verification of priority handling
    - Flow identification and traffic separation

2. Reason for Grouping 5GMM and 5GSM as NAS

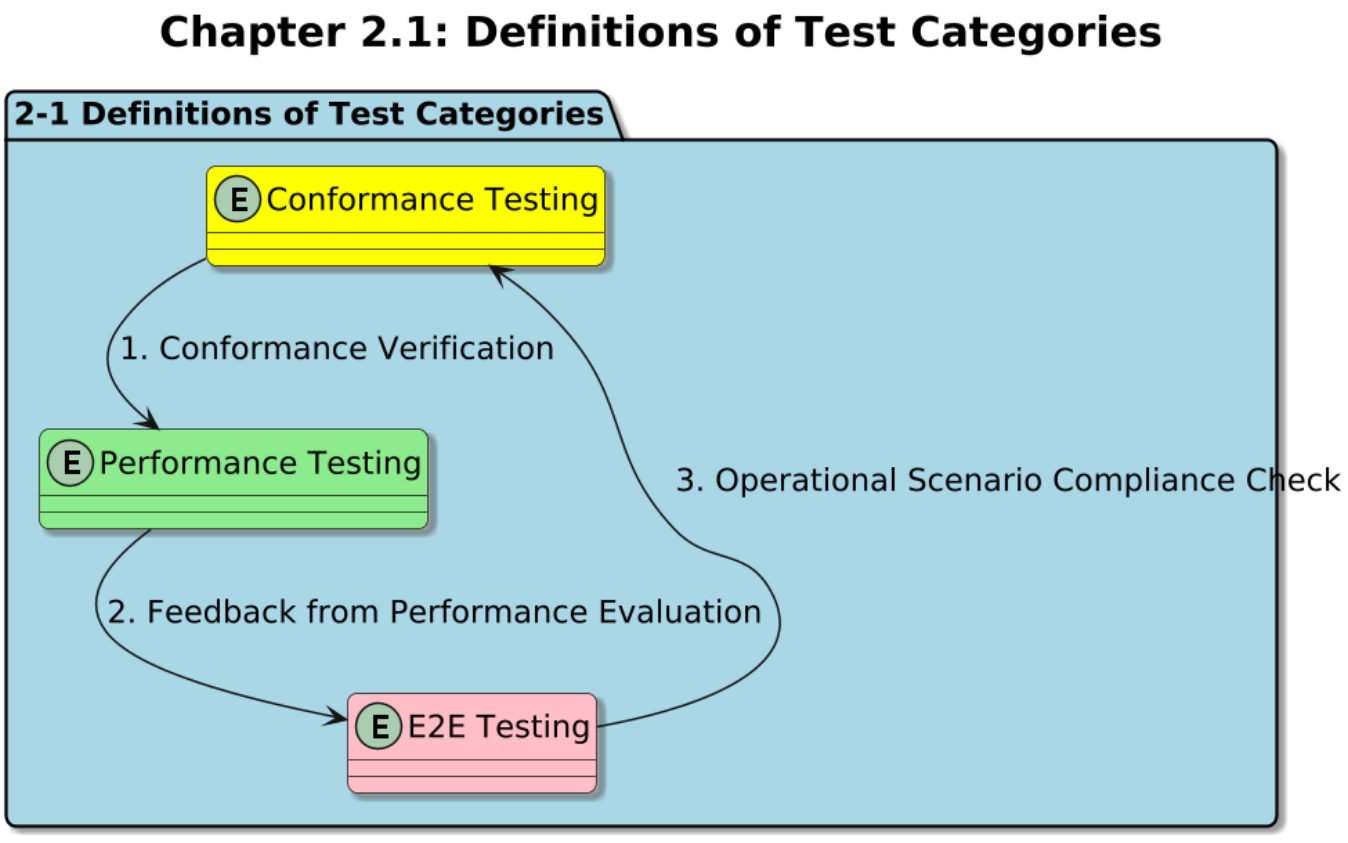
NAS (Non-Access Stratum) manages signaling between the 5GC and UE, encompassing both 5GMM and 5GSM. These two are commonly grouped under NAS in testing for the following reasons:

- Unified protocol structure: 5GMM and 5GSM both function as part of the control mechanism between UE and 5GC and utilize the same signaling path (e.g., NAS messages). Thus, specifications and tests often treat them collectively as “NAS testing.”
- Simplified testing approach: While it's possible to test 5GMM (mobility management such as registration, update, disconnect) and 5GSM (session management such as PDU session setup, modification, release) separately, conducting integrated NAS testing is more practical and efficient.
- Standard documentation methodology: In 3GPP specifications (e.g., TS 24.501), 5GMM and 5GSM are defined as separate functions, but in test documentation they are generally described together as part of the NAS protocol suite.

Conclusion

SDAP is not explicitly listed in test categories because it is implicitly validated as part of broader protocol stack evaluations, particularly through QoS flow integrity and PDCP-layer integration testing.

5GMM and 5GSM are grouped under NAS due to their shared signaling path and their cooperative function within UE-to-5GC communication. This grouping enhances test efficiency and aligns with 3GPP-compliant test design practices.



2.2 Practical Test Steps

Pre-test, Step-by-step Testing, Continuous Integration
This section describes practical procedures for effectively executing 5G MCS testing. The procedures focus on each component—UE, gNB, and 5GC—and cover the required test cases and expected outcomes at each stage. The process flow is also visualized in a diagram for clarity.

2.2.1 Overview of Test Steps

The practical test steps are categorized as follows:

- Setup: Construction and configuration of the test environment
- Connectivity Testing: Verifying basic connectivity between UE and gNB, and between gNB and 5GC
- Functional Testing: Verifying the functionality and performance of each component
- Interface Testing: Validating protocols and data flows across interfaces
- Stress Testing: Evaluating system behavior under high load conditions

2.2.2 Detailed Test Procedures

Detailed steps for each testing phase are described below:

2.2.2.1 Setup

- Prepare the required hardware and software
- Configure each component (UE, gNB, 5GC)
- Set up log collection and monitoring tools

2.2.2.2 Connectivity Testing

- Verify the connection between UE and gNB
- Establish RRC connection
- Confirm cell selection and reselection behavior
- Verify the connection between gNB and 5GC
- Confirm NGAP message exchange
- Establish SCTP connection

2.2.2.3 Functional Testing

- Registration Function Test:
    - Verify UE network registration behavior
    - Inspect 5GMM messages
- Session Management Test:
    - Verify PDU session establishment and release
    - Configure and validate QoS flows

2.2.2.4 Interface Testing

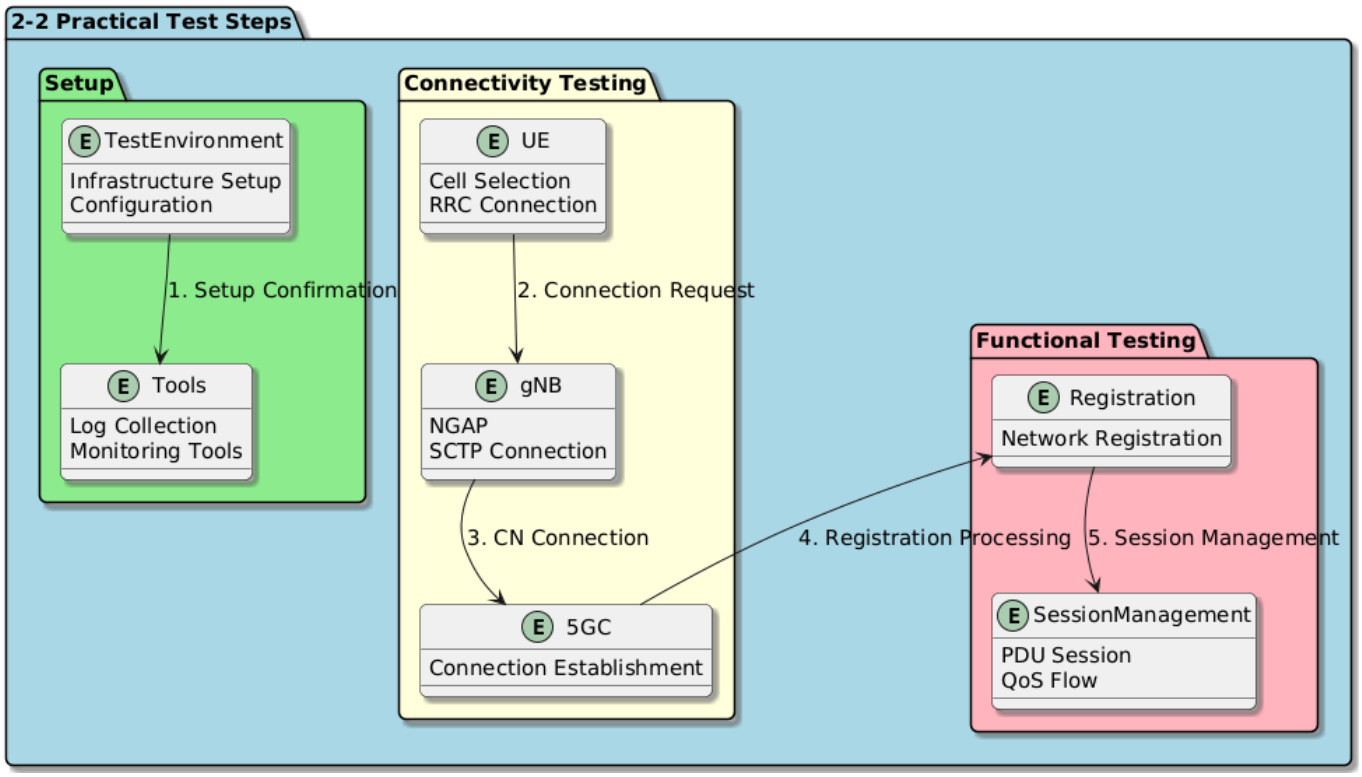
- N1/N2 Interface: Protocol validation from UE to 5GC
- N3/N6 Interface: User-plane traffic verification
- N4 Interface: Test UPF configuration changes

2.2.2.5 Stress Testing

- Simulate High-Load Environment:
  - Increase the number of simultaneously connected UEs
  - Generate high traffic loads
- Performance Measurement Under Load:
  - Measure latency, throughput, and error rate

2.2.3 Test Flow Diagram

The following diagram illustrates the test flow:



Chapter 3: Conformance Test

3.1 Objectives

3.1.1 Verification of Compliance with 3GPP Specifications

This section clarifies the objectives of conformance testing within the context of 5G MCS. Conformance testing is conducted to verify that the UE, gNB, and 5GC operate in compliance with 3GPP specifications, and to ensure interoperability between different vendors.

3.1.2 Primary Objectives

- **Verification of Specification Compliance:**
  Each component is tested to ensure it operates accurately according to 3GPP standards.
  Special focus is placed on the compliance of protocols such as RRC, NGAP, and PDU session management.
- **Ensuring Interoperability:**
  Connectivity and functional compatibility between products from different vendors are verified.
  Protocol integrity and data flows between the UE and gNB, and between the gNB and 5GC, are evaluated.
- **Improving End-User Experience:**
  The stability and performance of the overall system are tested to ensure a high-quality user experience.
  Key user-centric metrics such as communication latency, throughput, and error rate are assessed.
- **Readiness for Commercial Deployment:**
  Conformance testing identifies and resolves issues in advance to support proper system deployment in commercial environments.
  It also ensures compliance with legal and technical standards.

3.1.3 Objective Overview

The following diagram visualizes the objectives of conformance testing: