A New Methodology for Designing Next Generation Networks Components Type Approval Labs

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Abstract
This paper presents a new methodology for designing type approval Labs of next generation networks. This methodology is based on recognizing and categorizing of required tests, test methods, system under test characteristics, investigating and determining Lab structure based on protocol (system under test) features, Lab configuration and its modules. Against existing Labs, Labs which implemented based on this method will be complete, total and can cover all requirements. By these Labs all the conformance, functional, performance and interoperability tests can be done. In addition to these Labs can be used as a development platform for future products. To prove practicality of announced methodology, SIP type approval Lab designed and implemented based on these methodology steps.

1. Introduction
Improvement and fast development of the computer networks has lead to the convergence thought of telecommunication and data networks. Such a thought has made the basis of the creation of Next Generation Networks (NGN). Being completely confident about the correction of network and its component operation before implementation and improvement is a necessity for network administrators. So the existence of test procedures and test laboratories to analysis of the networks operation is more important than ever before. There are no comprehensive Labs and targeted test procedures covering all different next generation network’s components and protocols. Generally, the performed endeavors in this field are rather limited to the presentation of test and scenarios for small and mainly scattered parts of protocols. These Labs are designed and optimized just as a test bed to execute special tests, and there is no possibility to cover all required tests. We are going to present and investigate the designing and implementation methodology of comprehensive NGN component’s Lab.

The most and effective subject in all Labs is the identification of test suites to be done. Generally, the required tests can be divided into the following categories: Functional, standard Conformance, Performance and Interoperability tests.

This paper is organized as follows: at first, in section 2 and 3, we will study the designing methodology of next generation network’s Lab and then in section 4, based on mentioned methodology we will design an example Lab for SIP protocol to prove the correctness of the methodology. Finally, we conclude in Section 5.

2. Signaling protocol
One of the most important parts of NGN is selection of signaling protocol and the manner of its interoperability with the other network’s components. Both SIP1 and H.323 signaling protocols are used in next generation networks to call establish and control. Both of these signaling protocols provide mechanisms for call establishment and teardown, call control and supplementary services required by users, and the main difference between them relates to the manner of call control and signaling.

SIP signaling protocol was developed by IETF studying groups to establish, control and terminate multimedia sessions and also Internet telephony calls. This protocol is a text-based protocol that operates in the application layer [1].

1 Session Initiation Protocol
This protocol has been developed to aid in the move toward convergence of the existing Time Division Multiplexing (TDM) networks and data networks by allowing voice, video and data to be integrated over the same network. It provides a simple method of allowing users to establish sessions over a network. SIP has a structure more akin to HTTP than to complex telephony protocols such as SS7\(^2\). Because of its simplicity, openness, ease of deployment and compatibility with existing IP protocols, SIP is widely used by users, application vendors and telecommunication service providers.

3. Lab design methodology

The methodology used in the design of this Lab describes all required procedures and strategies to design and operate NGN component's type approval Lab which is based on key topics and concepts of test identification and classification, test methods, system under test (SUT), Lab objects, Lab structure, Lab configuration and Lab forming modules.

3.1. Identification and classification of required tests

The aim of quality assurance and type approval of a product is to completely validate the functionality, performance, conformance to standards and interoperability. Due to the concerning objectives, type approval test can be divided into the following parts [4, 7 and 8].

3.1.1. Functional testing

Functional testing verifies that the system is implemented in accordance with required features and specifications. Functional testing is testing without knowledge of the internal implementation of system, and system is verified based on its inputs and expected outputs [4, 6, and 8].

3.1.2. Conformance testing

The basic test in type approval test suite is verifying conformance of a protocol/standard implementation with official documents, and the operation and correctness of all tests depends on the correctness of these tests.

Conformance testing is a method to determine to what extent an implementation of a particular standard conforms to the individual requirements of that standard [4, 5, and 8].

3.1.3. Performance testing

The purpose of performance testing is measuring capacity of SUT, verifying long term stability, and also verifying that the system can work under different workloads, abnormal conditions and stress. After functional assurance, the performance of system under stress must be tested (stress testing). This test will be done in two different status of normal and peak operation conditions. In the performance test determined function(s) of system are verified under controlled conditions to evaluate the correctness of functions and measure delay, jitter and so on [4 and 8].

3.1.4. Interoperability testing

One of the most important problems of next generation networks implementation is come from non-interoperability between different vendors' products. Generally interoperability problems arise from incorrect implementation of related protocol, because some parts of protocols are implemented incorrectly to facilitate implementation or overcome technical and economic problems. Finding this problems are very difficult and expensive. Although a product may operate correctly with other products of the same vendors and solely but it may not have suitable interoperability with other vendors. The other reason is the great numbers of protocols and vendors. To overcome this problem, the products of every vendor must be tested with the product of other vendors. It is observed practically that time orders of such algorithm rapidly increases when the number of products and vendors increased.

3.2. Test results log and analysis

In general, implementation of all specification of a standard doesn't require and also it is almost impossible that a product can implement the entire feature. In this manner, it is necessary to classify standard specification and its features based on their application.

Products' features can be divided into mandatory and optional groups, and the levels of standard conformance are defined based on these groups. Each level covers a group of specification of related standard. Generally, level A is the main core of standard (protocol) and involves all the mandatory features. This level must be supported by all of products; otherwise product doesn't conform to standard and will not be approved. Level B involves level A and the supplementary functions which are recommended by standard. This level, regarding to special applications, can be divided to multiple sub-levels. Level C involves level B and the optional

\(^{2}\) Signaling System #7
standards features which are implemented for specific applications [13].

The only way to evaluate conformance test results is comparison the obtained results with expected results and determination the level of standard conformance.

The obtained results from performance test are classified in two main groups. The first group comprises of parameters for which different telecommunication institutes provide some standards and all telecom vendors and operator must be considered them. These standards are also the criterion of Lab decision. The comparison of standard amounts and test results is the suitable criteria to make a decision about product performance.

The second group is composed parameters that they don't have any valid standards. For example we can consider the call control simultaneous call rates. It is evident that no standard amount can be introduced for it, and its measuring criteria varies from network to network and from product to product, but as a general criteria for such parameters, we can consider the claim of the vendor as a criteria for decision making.

To do component type approval flow, a specific process must be determined in Lab. This process involves the product entrance to the Lab, test execution and issuing type approval license. The general type approval flow was shown in figure 1.

The technical specification documents for each product must be completed by its vendor or agent when type approval is asked. After completion of documents, product test flow is started, which is shown in figure 2.

The different type approval levels which were shown in figure 2 are determined regarding to the request of customers, and all the related tests will be executed in the requested level. The mandatory function and conformance of basic protocol specification are verified in level A. in level B, correctness of recommended functions, implementation of recommended protocol specification, and the performance of the product compared with the vendor’s claim are verified. Level C tests the correctness of all optional functions, optional protocol specification, and performance under critical conditions. Finally, if all of the tests are passed successfully, the product will be approved. In each level if the tests aren’t passed, the test report will be provided and presented to the vendors or its agent.

3.3 System under test

Identification of system under test and determination features of components is great importance in Lab network design. Since some protocols define its own network whose components have special tasks, and we must consider a special test suite and environment for each element. For example
SIP network is comprised of the following elements: user agents include user agent client (UAC) and user agent server (UAS), and SIP servers consist of proxy servers, redirect server and registrar. So, in design of SIP Lab, we must able to test all SIP network elements.

3.4. Lab objects and components

After the study of required tests, specification of test tools for optimized Lab designing should also be studied. Since the form of system under test specifications and required tools specifications has great impact on Lab architectural design.

3.5. Next generation networks tests tools

In order to test NGN components, some tools are introduced and developed. These tools have important role in the process of quality assurance. Using tools not only helps decreasing costs but it also contributes to product improvement trend. Tools help us be more confident in successful automatization of test suits, their repeatability and monotony in test cases [8, 10, 11 and 12].

Test tools used for testing the components of NGN should have some general and some special specification. The special ones are expressed based on protocol test or a special part of network that this tool is gang to test it, and general specifications of test tools are: [8, 10, 11 and 12] possibility of initiation and simulation the operation of network elements, ability of testing elements in different phases (for example signaling alone, signaling with media simultaneously, ...) supporting media and signaling protocols (including MGCP, H.248/Megaco, SIP, H.323, RTP and RTCP), having Ethernet physical interfaces, T1/E1, V.xx, supporting protocol Message/data with different formats, portability, suitable graphical user interface, permanent support, supporting and presenting timers, ability to produce required scripts, TCL supporting, TCP and UDP supporting, ability to execute user scripts, ability to improve for new elements and protocols, and ability to automation the test suits.

3.6. Lab structure

Design of logical and physical structure of Lab depends on two important issues, which are: protocols to be tested in each part of NGN and the kind and number of tests to be done in each part.

In designing the general structure of TA³ Lab, two important points must be considered: extensibility and test to be executable. Such a structure provides the possibility to Lab to coordinate itself with the technology trends. In the next sections we will have a more detailed study of blocks making TA Lab.

3.7. Methodology

The methodology used in Lab design based on key parts and concepts like definition of operational environments, definition of Lab parts configuration and how they will interoperate with each other and test execution resolution.

4. SIP Type approval Lab

Since this Lab is designed as a pilot of NGN component Type approval Labs, we first concentrate on independent designing of each operational part and finding environment requirements to perform all tests related to that protocol.

This is possible with the study of components and objects that comprise the Lab, required tests for each part and the specification of existing test tools.

After the independent designing of each environment we will try to optimize the structure and architecture of Lab with minimizing the required equipments, besides preserving independence of every part such that it has minimum dependency to the other parts in the future.

4.1. SIP protocol tests

After identification and classification of TA required tests, according to the mentioned classifications, the tests related to SIP Protocol were extracted from documents (if they had existed) or they were designed.

4.1.1. SIP conformance test

Based on latest studies, conformance tests of this protocol should be done on the basis of standard test ETSI TS 102 027-2 V2.1.1 [2].

4.1.2. SIP functional test

SIP protocol functional test, involves User Agent, Call Agent (SIP Servers) and Services tests [9].

- **User Agent test**
  - The objective of this test is to study the correctness of user agent function in SIP protocol.

- **Call Agent test**
  - The study of correct function of Call Agent (servers) in SIP relation protocol is the objective of this test.

- **Services test**
Objective here is to study the correctness of service operation in SIP.

4.1.3. SIP performance test

SIP Performance test consists of measuring the following tests: Transaction Response Time (TRT), Registrations per Second (RPS), Calls per Second (CPR), Transaction Failure Probability (TFP).

4.1.4. SIP-T tests

SIP-T protocol which standardized by IETF institute [3], consists of a set of mechanism for signaling connection between PSTN\(^4\) and SIP networks. The objective of SIP-T is to translate protocols and present features between SIP and PSTN.

SIP-T test involves conformance test of different parts of SIP-T as ISUP to SIP and SIP to ISUP tests.

4.2. Test tools

The required test tools for this Lab can be divided into two general categories that are: SIP Protocol test tool and PSTN test tool.

4.2.1. SIP test tools

SIP test tools should guarantee to execute protocol conformance, functional and performance tests. The key specification of these tools is necessary for conformance test based on standard of ETSI TS 102 027-1 and ETSI TS 102 027-2 for conformance with RFC 3261 of IETF institute, for functional test of servers simulation (proxy, registration and redirect) and user agents, simultaneous call generation, generating valid and invalid massages, massage analysis, and for performance test: generating SIP call traffic, simulate end points, generating simultaneous calls, measuring the call duration, and measuring the number of calls in busy hours are necessary.

4.2.2. PSTN test tools

Since the NGN need convergence elements and must interoperate with existing circuit switching networks such as PSTN, PLMN, etc that work with SS7, and because the existing telephony network of our country is PSTN and SS7 signaling, one of the important issues to be considered in NGN Lab is verification that NGN components can interoperate with the existing networks. So, we need PSTN simulator to do functional and performance tests. PSTN simulator simulates PSTN states and operation. It must be able to generate simultaneous PSTN calls, generate Toll quality calls, send and receive calls through gateway, simulate busy hour, simulate analog phones in various status (busy, hold, etc), generate and terminate ISUP/SS7 signaling messages, and analysis messages.

4.3 Sip Lab network architecture

Lab is comprised for two independent sub-networks lansip1 and lansip2 and a sub-network shown in figure 3 as IP PBX. In order to preserve the comprehensiveness of tests these sub-networks are considered independent and connected to each other by a router (in most test scenarios of this protocol we need such a configuration). It should be mentioned that the router used here will not necessarily be professional router; it can be a PC with several LAN cards that make connection between different sub-networks through routing protocol or manual routing.

In this Lab correctness of functional and performance test of SIP and SIP-T protocols in MGC, IP PBX, SIP Phones, SIP Servers and SIP Clients located behind a firewall can be tested.

For lunching this Lab beside Ethernet environment and router existing in figure 3, test tools are also required. Some tools are required for the execution of functional and performance test of SIP-T protocol and some others for SIP and SIP-T conformance, Monitor/Analyzer and Call generator/Simulator are also required.

The reason for selecting such a structure for this operational environment is that SIP introduces a network itself and for implementation of this protocol and using its facilities/services, we need minimum requirements shown in figure 3. It can simply be observed that the selected methodology let us select the required tools easily among the existing equipments and the existence of TA Lab design has created a comprehensive environment that has the ability to do all protocol related tests.

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\(^4\) Public Switch Telephony Network
to test tool and there is no any connection to other parts.

![Figure 4. SIP and SIP-T conformance environment](image)

The objects of this Lab are mentioned in table 1.

<table>
<thead>
<tr>
<th>Object</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIP / Server / Proxy</td>
<td>Device Under Test</td>
</tr>
<tr>
<td>DNS Server</td>
<td>Test Tools</td>
</tr>
<tr>
<td>SIP / SIP-T Monitor Analyzer</td>
<td>Test Tools</td>
</tr>
<tr>
<td>IP PBX</td>
<td>Device Under Test</td>
</tr>
<tr>
<td>SIP Client</td>
<td>Device Under Test</td>
</tr>
<tr>
<td>SIP / SIP-T Call Generator / Simulator</td>
<td>Test Tools</td>
</tr>
<tr>
<td>SIP Phone</td>
<td>Device Under Test</td>
</tr>
<tr>
<td>R1 (Router)</td>
<td>LAN Component</td>
</tr>
</tbody>
</table>

These objects are determined based on tests, test scenarios and SIP protocol specifications and guarantee that suggested sample approving Lab will have the possibility to do all related tests considering its structure.

5. Conclusion

Advantages of NGN Lab design can be expressed as follows: first, using the specified methodology, we can implement NGN components' Labs which are capable to perform functional, performance, conformance and interoperability tests. Second is the Lab extensibility, based on the presented methodology, we can design and implement the NGN components' Lab which is extensible. In this methodology, design methods use minimum number of facilities and test tools which reduce cost and room space needed for Lab. Labs designed in this way can be used as a base of development of products related to protocols, because of special attention to protocols.

6. References