IMS End-to-End Integration Validation Testing Approach

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Abstract: The IP Multimedia Subsystem (IMS) is regarded as the global Service Delivery Platform (SDP) standard for enabling network convergence and multimedia delivery applications. The objective of this document is to present the network Testing Strategy for IMS as the reference solution. The concepts presented in this document follow the Alcatel-Lucent holistic approach for solution integration and validation, which is linked to and part of the Alcatel-Lucent Advanced Integration Methods (AIM). The testing of the IMS solution referenced herein includes the network control layer and service layer (via a generic Application Server solution). This type of testing safeguards the essence of the IMS architecture which revolves around a universal open ended platform for providing services across both wireless as well as wireline terminals simultaneously. This document only deals with the Testing Strategy of an IMS Reference solution. As a next step, this document ought to be incorporated into the Solution Validation Strategy, which includes the definition of the Test Design, and Test Plan. Finally, Test Execution starts according to the defined Test Plan.

Keywords: AIM, IMS, Converged application, Migration, VoIP, End-to-End Testing.

1. Introduction:

Telecommunication is the science of communication over a distance. It could be communication of voice, image, video, and data between people, or services, like entertainment, or information to a large number of people over wireline or wireless technologies. A sample chapter on telecommunications evolution and future [1] has described the evolution and convergence of telecommunication aptly. The following diagram in paper [2] accurately represents the convergence evolution taking place.

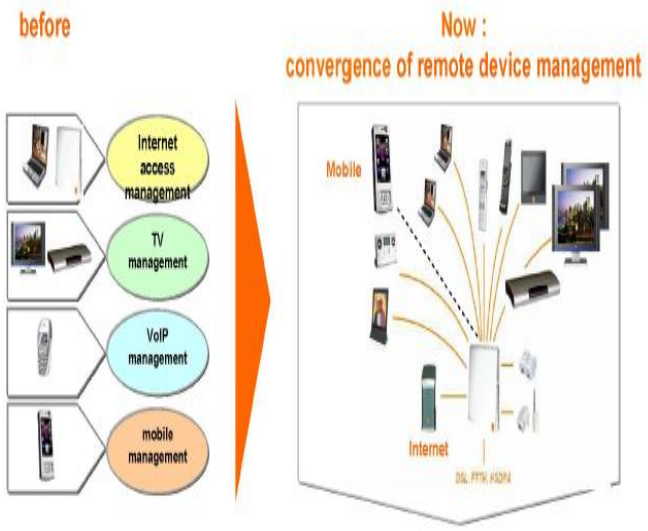

Figure 1:

As shown in figure 1, we are surrounded by a multi-level convergent media world where all modes of communication and information (e.g., voice, video, image, and data) are continually reforming to adapt to the enduring demands of technologies, changing the way we create, consume, learn and interact with each other. Quadruple Play is the new buzzword describing the triple play service of broadband internet access, television and telephone with wireless service provisions. This bundled service set is also sometimes humorously referred to as The Fantastic Four. Bundling has the potential for increasing data revenues for the Service Providers (SPs), however, they face challenges along the way. For bundling of services, integration is the first step. The key issue that must be solved is how integration will be done, given its complexity due to the many points of integration, and what the overall cost will be.

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2. End-to-End Integration/Validation Challenges:

In order to implement an effective network transformation, SPs must integrate their disparate access networks (e.g., PSTN, 2G/3G/4G, IP) with IMS as the core back-bone control network and with the applications servers to obtain a full end-to-end integrated solution. The success of such a solution is dependent, to a large extent, on the ability of the SPs to eliminate the complexity introduced by this network transformation [3].
The three most complex challenges for the SPs in integrating and validating the end-to-end network transformation are:

1. Multi-Domain Consolidation:
   Critical for success, an IMS-based solution should deliver any service over any medium. Such end-to-end functionality with scalability, security, QoS and QoE requires interoperability and interworking across all types of access networks, CPE and applications. The challenges for the SPs are:
   - To support multi-technologies used in different access networks
   - To support multi-vendor equipment components in and across network domains
   - Network transformation involving multi-domains has a huge impact on CapEx, OpEx with risk of project delays [4]

2. Migration Process:
   The success of such a huge-scale migration process requires predictability and methodology, such as:
   - Migrating to an IMS network with functionality to support the legacy network
   - Minimal impact on existing network infrastructure and services
   - Proven testing methodology, service validation process and tools
   - Resource planning, scheduling and fallback scenarios
   - Preventing any end-user outage time during migration
   - Overall migration cost

3. Network Integration and Validation:
   End-to-end network integration and validation is required to verify the behavior, on an end-to-end basis, of the control IMS network which is inter-connected to the access networks and application servers to deliver seamless services to the end-users. This requires:
   - Testing the solution in an end-to-end network environment in the way that the solution will be deployed and used in the field, hence, modeling the production network
   - Validating the interface level configuration requirements for all the Network Elements (NEs) included in the solution
   - Performing end-to-end traffic route testing for measuring QoS, performance and reliability of the IMS solution
   - Executing end-to-end call flow testing for all of the features and services to be provided by the solution using same call /traffic models as the ones going to be implemented in the production network
   - Validating each IMS element to ensure that multi-vendor network components interoperate correctly, support the IMS network with no unnecessary complexity and have no technical errors
   - Validating the end-to-end network solution validation process itself, so as to make it repeatable as the solution evolves over time

3. Alcatel-Lucent's Integration/Validation Solution:

Alcatel-Lucent has invested massively to develop enhanced capabilities to support complex, multi-vendor network transformation

programs. Alcatel-Lucent's end-to-end solution validation methods have helped its customers to:

- Reduce time to market
- Reduce risk of project delays
- Reduce customer lab footprint requirements
- Add test and integration capability

Testing is often done as a back-end process, with tests focusing mainly on functional aspects, such as making a voice call. However, the non-functional aspects often do not get enough attention, such as validating the operability of the solution, scalability testing, individual behavior of NE, black box behavior of NE, and end-to-end load testing in representative field conditions. While one is developing the network requirements, validating the requirements, and identifying for each requirement a verification method, doing criticality and risk analysis might be more cost-effective than doing a back-end test process. Thus, the Alcatel-Lucent Integration/Validation testing approach is a more holistic approach.

In summary, the principles of the validating methodology for the IMS solution should be:

- A logical, reproducible progression to ensure that the end-to-end IMS solution meets its design requirements and user needs
- To test the IMS-components in an end-to-end network environment
- To fully validate the solution on an end-to-end basis based on the defined requirements

4. Network Testing Strategy for IMS

The testing strategy is an outline that describes the testing approach to be implemented during solution integration, verification, and validation. However, before the solution is verified and validated, the solution must be integrated. Before integration, the lab needs to be designed. During lab design, tools are developed and the solution components are installed and commissioned in the lab. The iterative integration process can start and a set of integration tests cases are executed. A complete integrated test lab environment should be designed with the purpose to verify and validate the IMS solution on an end-to-end basis. The NE should go through entrance criteria prior to integrating them in the lab. The testing strategy can be grouped into three phases:

Phase 1 (Integration). It includes:

- NE platform readiness testing
- NE interoperability and feature functionality testing
- End-to-end integration

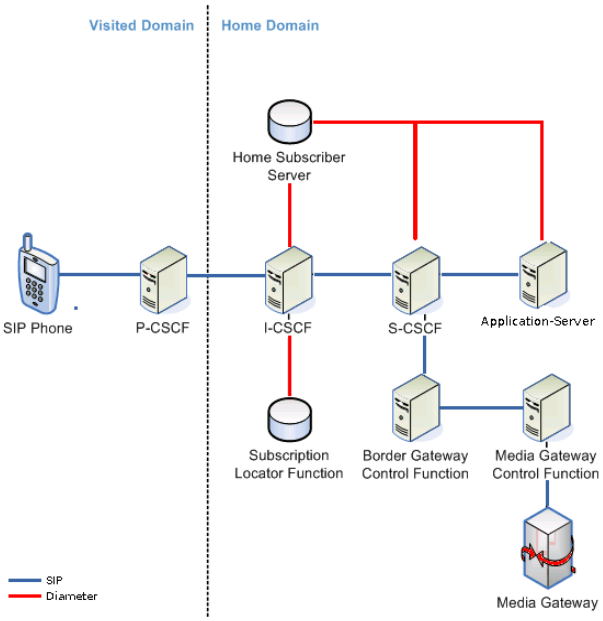
Phase 2 (Verification). It includes:

- Solution-based call flow testing
- Solution-based call processing capacity and performance testing
- Security testing

Phase 3 (Validation). It includes:

- Final solution validation testing based on production migration sequencing and full regression testing

Reference [5] discusses IMS entities and key functionalities classified into six main categories: session management and routing family (CSCFs), databases (HSS), interworking elements (BGCF, MGCF, MGW), services (application servers), support entities and charging. The following figure [6] shows a high level NE view of a generic IMS solution.



Based on reference [6] and the phases outline in the above section, the details of the Testing

Strategy for an IMS solution are presented below.

6.1 Phase 1 (Integration)

6.1.1 NE Platform Readiness Testing

The following high-level of testing should be performed for each NE:

- NE health checks
- NE configuration as per standards
- NE backup and restore
- Network interface failures
- NE local redundancy scenarios with switchovers and failovers
- Establish and validate NE connections to interfacing network elements
- Validate basic subscriber registration and call scenarios

6.1.2 Sample of NE Interoperability and Feature Functionality Testing in an IMS Solution

This section lists areas of testing for network element's feature functionality and interactions with other interfacing NE.

6.1.2.1 Element Management System (EMS)

- NE fault management/ performance management/ configuration management support for the IMS network elements
- Configure new NE on the EMS
- NE status and connection functionality (sunny day and rainy day)
- NE configuration management functionality via EMS
- NE alarm generated are displayed on the EMS
- NE performance measurements collection on EMS

6.1.2.2 CSCF Function Testing

- CSCF – BGCF interaction testing
- CSCF – Application Server (AS) interaction testing
- CSCF – Diameter testing
- CSCF – Charging function testing
- Subscriber registration, re-registration and de-registration
- Multiple service profiles for different services
- Geographic redundancy support of CSCF failure scenarios

6.1.2.3 BGCF Testing

- Signaling gateway function, SS7 interaction testing
- BGCF – S-CSCF SIP interaction testing
- BGCF – media gateway interaction testing
- BGCF call routing
- BGCF geographic redundancy scenarios

6.1.2.4 Media Gateway Testing

- Media Gateway – Media Control interaction testing
- H248 message validation support of call flows
- Validation of media port and bandwidth functionality

6.1.2.5 Media Resource Function Testing

- MRF announcement functionality interactions
- MRF conference functionality interactions
- MRF CALEA functionality
- SIP message validation support of Call Flows
- Validate MRF services functionality
  - Announcements playback, variable announcements, customized announcements
  - Conference circuits
  - DTMF collection
  - Legal Intercept – CALEA
  - Codec support G711 and AMR
- Geographic redundancy support of MRF system failure scenarios

6.1.2.6 Application Server (AS) testing

- AS – CSCF interaction testing
- AS – CSCF Diameter interaction testing
- AS – Charging interaction testing
- AS – MRF interaction testing
- SIP message validation support of call flows
- Subscriber services testing

    - Call forward, call wait, call transfer, Simultaneous ring, 3-way call, etc
    - Voice mail deposit, retrieval
    - Call trace, connected line ID, etc
- Geographic redundancy support of Application Server system failure scenarios

6.1.2.7 Session Border Controller (SBC) Testing

- SBC – CSCF interaction testing
- SIP message validation support of subscriber registrations and call flows
- Geographic redundancy support of SBC failure scenarios
- SIP message validation support of cal flows
- SIP message validation support of subscriber registrations

6.1.3 End-to-End Integration Testing

- Confirm SIP message flow and content, NE by NE.
- Basic calls (UE <-> UE, UE <-> PSTN)
- Call redirection (e.g. call forwarding, announcements, click-to-dial, simultaneous ring, voice mail etc)

6.2 Phase 2 (Verification)

6.2.1 Solution based call flow testing

- Multiple call e.g. three way conference calls
- Inter-service domains
- Emergence service calls
- Inter-region call scenarios

6.2.1 Solution based call processing capacity and performance testing

In addition to the summary of test areas and reference requirements, the following scenarios should be evaluated for capacity and performance testing:

- Sustained call loads running at sunny-day geo-redundant site engineered capacity level
- Sustained call loads running at failed geo-redundant engineered capacity level
- Validation of surviving site handling of messaging storm of geo-redundant site failure
- Validation of recovering site handling of messaging storm of geo-redundant site failback

6.2.2 Security Testing

Validate security guidelines as defined for the specific network design such as:

- Verify security hardening procedures per NE
- Password complexity and expiration parameters
- Verify ports and protocols
- Verify with non-default login/passwords

6.3 Phase 3 (Validation)

Final Solution-Based Validation/Regression Testing

Perform final solution validation regression testing of the end-to-end IMS-based solution, including:

- Verify a subscriber functionality test suite for IMS services
- Verify billing functionality
- Verify EMS operations and alarming
- Verify non-failure and failure conditions/call flows
- Verify fault/redundant paths and alarming (failover condition and failback)

6.4 Summary of benefits by implementing this testing strategy for an IMS reference solution

Alcatel-Lucent's end-to-end testing strategy engaging IMS as the network-based solution will generate the following benefits to SPs:

- Prevented Cost of non-quality: A rigorous testing methodology will result in fewer defects once the solution has been implemented in the production environment. On the contrary, an ill tested solution will not work well in the field. Hence, a large number of fixes will be required, which are costly and lengthy to reproduce and resolve. Further, end-user satisfaction will be seriously impacted, which in turn, will impact competitiveness of the SP in the market place.
- Reduced Time to market the solution: The solution will be implemented and

roll out into the field much faster. As a result, the SPs will accrue more revenue and faster. Market share, and competitiveness will be significantly improved..

- Improved Solution's Business case: A well tested solution will generate fewer defects during the solution's roll out and operation. As a result, cost savings in maintenance act ivies, and repairs will be accrued, which in turn, will benefit the overall business case for the delivery of the solution.

Conclusion:

This paper focuses on the testing strategy aspect of the reference IMS solution, which is linked to and part of the Alcatel-Lucent Advanced Integration Methods (AIM), a holistic approach for solution delivery. The study reported in this paper focused on the testing strategy of a generic IMS test bed environment with the goal to integrate, verify, and validate all major IMS core components, including x-CSCF, HSS, MG, MRF, application servers, and EMS, into one single environment. This document should be incorporated into the Solution Validation Strategy (SVM), as defined by AIM. Lessons learnt from our solution validation experiences can be used and extended to R&D activities by academic and industrial partners. Also, to the community involved in converged application development, testing and deployment. Our experience shows significant benefits in defining and implementing a detailed testing strategy as the one described in this paper. Specifically, there are cost benefits, in terms of time and resources, as well as, in time to market the IMS-based solution. Those benefits will have a noticeable impact on the SPs bottom line.

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Acronyms:

3GPP	3rd Generation Partnership Project
AIM	Advanced Integration Methods
AMR	Adaptive Multi-Rate
AS	Application Server
BGCF	Breakout Gateway Control Function
CALEA	Communications Assistance for Law Enforcement Act
CapEx	Capital Expense
CPE	Customer Premise Equipment
CSCF	Call Session Control Function
DTMF	Dual Tone Multi-Frequency
E2E	End-to-End
EMS	Element Management System
HSS	Home Subscriber Server
IMS	IP Multimedia Subsystem
MG	Media Gateway
MOP	Method of Operation
MRF	Media Resource Function
NE	Network Equipment/Element
OpEX	Operational Expense
S-CSCF	Serving-CSCF