Experiences on the Establishment and Provisioning of NGN/IMS Testbeds - The FOKUS Open IMS Playground and the Related Open Source IMS Core
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Abstract – In this paper we share our experiences on establishing, running, and extending a Next Generation Network (NGN) and IP Multimedia Subsystem (IMS) testbed. The testbed has been designed based on the layered architecture of NGNs and aims at satisfying Information and Communication Technology (ICT) industry requirements for open and flexible testing infrastructures. In the center of this telecommunication technology oriented testbed an open source IMS project has been established for the benefit of the IMS research community. Throughout the paper we will give insights into the structure of the NGN/IMS testing environment and the associated open source developments. It will be described how operators, vendors, and the academia can benefit from the open NGN/IMS testbed solution and how this infrastructure helped in the development of IMS test tools and standardization. Furthermore, an approach to current challenges such as NGN/IMS management and service orchestration will be outlined in face of Service Oriented Architecture strategies.

1 Introduction

In the context of Next Generation Networks, the IP Multimedia Subsystem (IMS) standardization is regarded as key for the architectural design. The IMS, originally defined by the 3rd Generation Partnership Project (3GPP) [1] and then embraced by many other organizations (e.g. with ETSI TISPAN [2] for its Next Generation Network (NGN) architecture [3], with the Packet Cable Initiative of the CableLabs [4], with 3GPP2 as part of its Multimedia Domain [5] etc.), was developed to address network convergence challenges and end-user requirements. The IMS is the unified telecommunication industry approach toward an “all-IP” network architecture that merges the paradigms and technologies of the Internet with the cellular and fixed telecommunication worlds while catering to carrier grade usage. It aims at creating a reference service delivery platform for provisioning IP-based multimedia services in a reliable, secure, and controllable manner. With the intention of contributing with research results and prototype validations, the Fraunhofer Institute FOKUS has been operating the Open IMS Playground [6] since July 2004. It serves as a testbed that brings together the R&D domain, commercial IMS solutions of major vendors and FOKUS-own IMS prototype solutions. As a unique open and vendor-independent IMS test environment it can be used as a testbed by academic and industrial institutions for early prototyping of new IMS related components, protocols, and applications, as well as for testing and benchmarking of NGN components. With all this expertise, FOKUS has become a leading research institute in the field of open communication systems and is also envisaging interconnecting its infrastructure with other IMS testbeds worldwide in order to allow the experience of NGN concepts and services to be shared with partners and contributing on defining the evolution path towards NGN.

In the light of current and upcoming European testbed projects and initiatives the importance of extensive testing of emerging telecommunication technology platforms, paradigms, and services, even in early design stages, is beyond doubt. With its long experience in operating testbed infrastructures, the FOKUS testbed environment also plays a major role in that context. This paper will outline the general concepts around NGN research and IMS testbed operation and will illustrate the lessons learned. The second chapter of this paper describes the general requirements for the operation of NGN testbeds while chapter 3 will outline the concept that the Open IMS Playground is following to enable also other parties to join in on IMS research. The fourth chapter will show how the environment catered to establish testing solutions for IMS networks. In the fifth chapter we will draw some conclusions on the major lessons that we learned during the years of operation and especially where we see topics to address beyond current standardization work.

2 NGN Concepts and Related Testbed Requirements

The Open IMS Playground has been designed and deployed following the layered structure of NGNs. High emphasis has been put on moving away from silo
solutions to this layered approach that allows the control of signaling information while enabling the re-use of features and enablers across the application layer. Figure 1 shows the layered NGN architecture which clearly separates transport, session control, and application layer and connects them via well defined interfaces. The components which are actively developed at FOKUS can mainly be found in the session control and application layer and represent our main research scope. Despite looking into concepts like QoS reservation in the transport layer, we consider IP connectivity as a given fact for operation thus, the testing of the transport layer will not be discussed further in this paper. Using standardized access/transport layer technologies we are able to use fixed or mobile devices (running an IMS client) to communicate with any fixed/mobile network. Within the session control layer, a specific focus has been put on the core signaling elements of an IMS which will be discussed further in chapter 3.

Figure 1: The layered NGN approach to service provisioning

The application layer logically hosts also enabler components such as an XML Document Management Server (XDMS) or a Presence Server but also application servers of the IMS such as e.g. a SIP Application Server or a Parlay X Gateway. A NGN testbed should unite as many of those functions as possible in order to allow meaningful demonstrations. But there is also a set of specific requirements on open NGN testbeds, like the Open IMS Playground, which reflect the Information and Communication Technology (ICT) industry needs.

Over the last and current decades we have witnessed a fast penetration of new ICT in society. The ongoing convergence of telecommunications, Internet, and media means that all actors in the new value chain need early access to an increasingly diverse range of end systems, network technologies, and service platforms. Open testbeds are an important means of providing such complex enabling infrastructures to speed up innovation in the NGN field. The basic goals of such testbeds are interoperability testing, benchmarking, and prototyping of technology extensions and innovative multimedia applications.

The interworking of different NGN services and/or network architectures provides convergence across services, network media, and access technologies. Industry-wide adoption of unifying standards creates the possibility of establishing interoperable systems spanning various organizations and countries. This draws specific requirements on testing such systems. In order to efficiently deploy and operate an open testbed (potentially within a federation of testbeds) considering the challenges mentioned above, there are requirements that must be fulfilled. The objective of this section is not to provide an exhaustive list of requirements, but to describe the ones we consider to be important. These are:

- a flexible network architecture: the challenge is to support different composed services running above a variety of access networks and at same time decreasing costs. This includes easy deployment and operation of new network technologies;
- use of mature, robust, and fault tolerant technologies that provide reliability, safety, security, autonomy, availability, and privacy to individual services as well as the overall integrated system;
- heterogeneous network interoperability in fully distributed environments with explicit support for increased bandwidth, optimized streaming and broadcasting, as well as mobility support;
- the dynamical management of platforms and services, as well as network management, and monitoring solutions and tools;

3 The Open IMS Playground and its Open Source IMS Core

The Open IMS Playground located at the Fraunhofer Institute FOKUS in Berlin, Germany, has managed to establish a vivid testing environment for trialing new services in the fixed mobile convergent domain or with respect to e-government or community and Web 2.0 applications based upon a combination of self-developed IMS prototype components and best-of-breed carrier-grade IMS solutions of commercial vendors.

3.1 The Open Source IMS Core

The Open Source IMS Core (OSIMS) project [7] started more than 3 years ago at Fraunhofer FOKUS as a development of the SIP Express Router [8] towards
Next Generation Networks and has formed the heart of the Open IMS Playground since its beginning. We used as a basis the SIP Express Router, for itself a highly successful Open Source project originally also initiated by Fraunhofer FOKUS and one of the world’s most used SIP proxies, due to its very good performance and extreme flexibility.

The initial target of the project was to develop first time prototypes of IMS core components (the Proxy, Interrogating, and Serving Call Session Control Functions (CSCF) as well as the Home Subscriber Server (HSS). Since they operate at the very heart of IMS signaling, these components have been successfully validated throughout the years with many commercial IMS components that got deployed in the Open IMS Playground.

While Figure 2 shows the components and setup of the Open IMS Core, we will also outline what major functions in the context of IMS session controlling it currently supports.

！Figure 2: The Open Source IMS Core setup

a) The Proxy-CSCF
As the first entry point in the IMS network for the User Endpoints, the P-CSCF has the role of a secure outbound proxy. Currently it is able to follow up on user registrations and to keep locally a reversed registrar that allows it to assert user identities and refuses access to unauthorized users. To secure communications, two methods can be employed: IPSec together with the AKA authorization [9], or TLS. Furthermore, the P-CSCF is checking and enforcing the correctness of the signaling at different levels, like transaction, dialog routing or general routing policies.

b) The Interrogating-CSCF
The I-CSCF is capable of doing Network Domain Security checks, capabilities selection, full Cx interface [10] support for retrieving the user status as well as serial fork requests towards S-CSCFs.

c) The Serving-CSCF
The main function of the S-CSCF is to keep the registration status of the users and for this purpose a special optimized and extended IMS registrar has been implemented. For authorization, a broad range of methods are available, like AKA (v1 and v2), MD5, 3GPP’s Early-IMS [11] or ETSI TISPAN’s NASS-Bundled authentication approach. They are of course coupled with a full Cx Interface implementation. Also very importantly, the S-CSCF is capable of triggering services through initial Filter Criteria checking and communication to application servers on the ISC interface.

d) The Home Subscriber Server
The main function of the HSS is that of a user profile database. The current implementation allows the configuration of user identity bindings to subscriptions and of course the definition of service profiles and initial Filter Criteria. In order to operate with as many networks and clients as possible, we added the support for many authentication methods and reference points [10, 12].

In November 2006 at the 2nd FOKUS IMS Workshop [13], the project was officially started under the GPL and its workshop was embraced by hundreds of participants. The development is hosted at the Open Source platform BerliOS [14] and since then, it has attracted more than 25,000 visitors worldwide from vendors, telecommunication R&D departments and from universities which now are providing feedback, improvements, and additions to the software at a steep pace. It can be stated, the FOKUS managed to establish a vivid community around the topic. Currently, the project’s target is to extend the components and to create convergent IMS Core elements. In addition to the existing verification through the successful operation with vendor components in the context of the Open IMS Playground, its interoperability is constantly tested and improved within the community. Of course, the Open Source IMS Core has been successfully tested with first IMS client implementations but offers also support for some VoIP clients.

3.2. Enabling New IMS Testbeds

With the deployment of the OSIMS components, a basic IMS testbed can be set up very rapidly at virtually no cost. In combination with the also freely available OpenIC_Lite [15], an implementation of an IMS client,
basic IMS scenarios such as voice calls are possible but most importantly it allows the triggering of certain applications based on user service profiles. Everything that is needed to demonstrate main IMS concepts is therefore publicly available. Research facilities of universities, operators, and vendors that are interested in IMS and NGN prototype testing can start making their own experiences by downloading the OSIMS code and installing the components at their own facilities.

Once set up, this basic testbed setup can either be connected to the Open IMS Playground in Berlin in order to benefit from the results around R&D for peer-to-peer concepts or IPTV activities in the Next Generation Media Lab [16] remotely or it can be extended locally by FOKUS “add-on” components (e.g. a SIP AS, a Presence Server, a fully featured IMS Client, a XML Document Management Server, or demo applications). In addition to enabling research related testbeds, FOKUS also successfully helped in deploying industry testbeds with prominent partners and operators (e.g. the Deutsche Telekom Laboratories).

In any case, the concept of distribution of a freely available nucleus for NGN testing already enables the development of new IMS applications to demonstrate the full potential of IMS. Application developers can now concentrate on the application layer while forgetting about transport and session control which is handled by the IMS Core components.

3.3. The Open IMS Playground on FIRE

As a last aspect regarding the Open IMS Playground, we want to highlight future directions for European ICT research in face of the EU-funded framework programs. The European Union funded FIRE initiative (Future Internet Research and Experimentation) [17] provides the research basis for the future Internet within the Framework Program 7 (FP7) and is represented by “Objective ICT-2007.1.6: New Paradigms and Experimental Facilities” of the second ICT call for proposals. Interconnected testbeds as a European federation of testbeds shall provide testing support for service architectures, infrastructures, and software platforms and pave the way for an early stage testing of new paradigms. The support for national initiatives is explicitly in scope for FIRE. In addition to those main objectives, the FIRE initiative is expected to drive research in the area of future Internet concepts, protocols, and architectures, in order to overcome actual Internet problems (e.g. spam, viruses, denial of service attacks, and complexity of management). These objectives are to be deployed considering technological, industrial and socio-economic aspects.

The FP6 projects Panlab [18] and ONELAB [19] can be seen as the two main drivers for the „experimental facility“ of the FIRE initiative. FOKUS is a Panlab partner and the Open IMS Playground is used as a field study and demonstration testbed within Panlab to show and validate Panlab mechanisms. The Panlab federation of testbeds will contain a nucleus of well-known and industry-accepted testbeds, which will be supported by a central Panlab office. The federation shall be open for other testbeds to join in under certain requirements. Whenever specific technologies are missing within the federation of Panlab partner testbeds and cannot be provided within the expected time frame, a “call for testing” will be launched in order to allow promising partners to join the federation. This stimulates innovation which is beneficial for the entire European industry.

In addition to the technical aspects, Panlab also focuses on legal (contract templates, legal form of Panlab federation/office, and supporting legal documents) and administrative (IPRs, business model, etc.) issues. Important outcome of Panlab will be a classification of testbeds, the definition of an advanced central testing search tool, as well as a test results repository for storage, lookup, and reproduction of previous testing results (legal and business issues also play a central role here).

4 Enabling the Development of IMS Testing Solutions

With respect to enabling testing solutions for IMS, the Open Source IMS Core prototypes are also often used in R&D and the industry to assess performance but also to establish conformance and interoperability tests for future networks with practical rather than theoretical estimations.

The Open Source IMS Core was accepted by many organizations as a reference prototype for testing IMS and associated services. It specifically serves as a reference implementation for the Special Interest Group for IMS/NGN Performance Benchmarking at ETSI TISPAN. FOKUS participated in this group and helped to publish the series of specifications [20] and publications [21], [24].
The tools that were developed in this context, allow a defined measurement of the performance of IMS core elements in defined steps. Figure 4 shows the benchmarking procedure.

Figure 4: The IMS Benchmarking procedure

In addition to the work in IMS performance benchmarking, FOKUS is also developing IMS conformance and interoperability test suites that are currently being discussed and standardized with many groups (e.g. ETSI TISPAN, 3GPP, GSMA or the MSF).

5 Lessons Learned – Supporting to Build NGN Services Based on SOA Principles

Over the more than three years of operation and management of this open IMS test environment and in the collaboration with national and international R&D projects, we have gained some experiences on shortcomings before making the IMS as a whole best usable for network operators. The two main findings that we observed were:

- the lack of defined management procedures and standards of integrated NGNs with respect to e.g. monitoring or dynamic provisioning
- the lack of supporting dynamic integration of telecommunications and Web 2.0 services under exploitation of Service Oriented Architecture (SOA) principles, focusing on both end system based as well as server-based service orchestration.

We think that telecommunications companies providing services for both, end users and business partners, can profit from SOA-based approaches in management and service creation to considerably increase their flexibility in reacting to future challenges [22]. Despite the term being used widely these days, studies showed that there is few experiences in the telecommunication domain and that there are uncertainties with regards to open vs. proprietary SOA solutions and that the integration of organizational management and IT processes is often far down the road. Following the main views on what a SOA is and keeping it simple, we identified two different approaches to SOA:

a) the Management View
From this viewpoint, SOA is regarded as a management concept or a vision for enterprises. The idea is to carefully define business processes and workflows based on services which are mapped onto modular and reusable IT infrastructures. This approach is useful as it allows for high flexibility on a process design level and an effective IT infrastructure at the same time. The outcome is an effective management of dependencies among different activities and utilization of specific information for scheduling, distributing, and coordinating work activities among human and information system resources. Also the interaction with business partners becomes more flexible and easier through SOA deployment.

b) the Technology View
From a technology point of view most SOA approaches are nothing new at all. On the technology level, SOA can be reduced to a “good programming style” or general programming principles. Services to be used within a SOA should be designed in a modular and reusable fashion while components need to be published and described in a standardized way in order to enable interoperability.

The reason why SOA has the potential to become a true success is that it is regarded as a valid approach on both management and IT levels. In addition to the general viewpoints described above we developed a specific view on SOA from the telecommunications perspective. Telecommunication is all about services which are offered by the network and that are made available by service providers. The telecommunication companies have a strong need to explore SOA capabilities and position themselves in face of the SOA trend which is considerably gaining momentum.

We think that SOA within the telecommunications environment stands for the provision of network technology independent and reusable service capabilities, such as call control, messaging, flexible charging, user location, presence information, content push, etc. which could be used and combined on demand for the implementation of new telecommunication services. The main drivers for considering SOA in the telecommunications world is the dream to have a Lego brick system for telecommunications, which enables much faster and more cost economic service implementations based on reusability of and competition between available service components.

Thus, in order to provision telecom oriented service capabilities based on state of the art SOA principles to
an open set of business domains, FOKUS opened in July 2007 the Open SOA Telco Playground [23].

![Open SOA Telco Playground](image)

**Figure 5: The Open SOA Telco Playground topology**

The Open SOA Telco Playground again co-operates with industry partners to establish a unique SOA testing and development environment for open and standardized solutions with a strong emphasis on the special needs of the telecommunications industry. Its mission is to support telcos in designing their individual SOA strategy and implementing specific solutions as well as developing new business processes while improving work flows and making use of legacy systems within an enterprise-spanning SOA.

6 **Summary**

With this paper we outlined how operators, vendors, and the academia can benefit from the open NGN/IMS testbed solutions at the Fraunhofer Institute FOKUS. Beginning with a general introduction on NGN concepts and an analysis of the ICT industry requirements, we showed how the Open IMS Playground is structured and outlined the main features of its long year nucleus, the Open Source IMS Core. We showed the concept of how the Open IMS Playground software prototypes can assist in enabling solutions for NGN and IMS testbed deployment, application prototyping, and testbed interconnection and we outlined briefly, how the Open Source IMS core helped in the development of IMS test tools. Finally, we presented the lack of NGN management solutions and the possibility to orchestrate services of the IMS and the web as one of the major points for future work with respect to testbed operation and how we think that SOA-based approaches will provide a solution for telcos to overcome these challenges.

7 **Bibliography and Links**

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