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Softswitch architecture remodelling for new generation IP Multimedia Subsystem environments

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Abstract. Widespread adoption of the next generation concepts in telecommunications has substantially affected the overall system architecture as well as each network element in particular. The softswitch is a heterogeneous control, service and management element. It is composed of several different logical functionalities that are vital to system operation of any kind and whose migration strategy has not yet been clearly defined. We present a general strategy of softswitch remodelling to meet IMS requirements and characteristics that might be interesting for different softswitch providers with respective architectural options in fixed or wireless domains. In the proposed solution, the initial softswitch architecture is presented in an independent and generalized way. Additional feature enhancements provide virtual parallel protocol environments inside a softswitch, each enabling specific advantages common to its features. The SIP segment is separated and introduced as an independent subsystem. Further architectural modularity assures a level of independency between parallel protocol environments and future openness with regard to IMS requirements. As a result, the IMS softswitch encompasses basic SIP/IMS functionalities while some of the existent compounds take over different roles of element interworking functions and partially functionalities of standalone IMS entities. The proposed solution is limited to basic functionalities and is of a smaller scale but is open and IMS-ready.

Keywords: Softswitch architecture, Next Generation Networks (NGN), IP Multimedia Subsystem (IMS).

Preoblikovana arhitektura klicnega strežnika za IP multimedijske podsisteme nove generacije

Povzetek. Uveljavljanje konceptov nove generacije v telekomunikacijah prinaša preoblikovanje celostne arhitekture sistemov kot tudi posameznih elementov znotraj le-teh. Klicni strežnik v omrežjih nove generacije je heterogen krmilni, storitveni in upravljalski element, zgrajen iz različnih logičnih funkcionalnosti, ki so z vidika delovanja sistema ključnega pomena. Zato je zelo pomembno skrbno načrtovanje postopne migracije, ki vključuje nove vendar preverjene koncepte in metode omrežij nove generacije. V tem prispevku predstavljamo splošen predlog strategije preoblikovanja klicnega strežnika v skladu z zahtevami in značilnostmi, ki izhajajo iz IMS koncepta, ki ni vezan na konkretni produkt, ampak je primeren kot predlog za ponudnike klicnih strežnikov tako fiksne kot mobilne domene, ki se nahajajo na različnih stopnjah migracije proti NGN/IMS. V predlagani rešitvi je začetna arhitektura klicnega strežnika, ki je opredeljena neodvisno in splošno, nadgrajena z dodatnimi zmogljivostmi, ki ustvarjajo navidezna vzporedna protokolna okolja v klicnem strežniku. Skladno z načeli IMS koncepta je SIP segment ločen in v arhitekturi nastopi kot samostojni podsistem. V arhitekturo je vnesena višja stopnja modularnosti, ki zagotovi večjo neodvisnost delovanja posameznih protokolnih segmentov, obenem pa zagotavlja odprtost in razširljivost, kot predvideva koncept IMS. Rezultat migracije je IMS klicni strežnik, ki obsega osnovne SIP/IMS funkcionalnosti, nekatere obstoječe komponente pa služijo za izvajanje funkcij medsebojne povezljivosti z okolico ter deloma nadomeščajo nekatere zmogljivosti, ki jih sicer zagotavljajo samostojne IMS entitete. Predlagana rešitev je omejena na osnovne funkcionalnosti in je manjšega obsega, prinaša pa odprtost in je konceptualno zasnovana skladno z določili IMS koncepta.

Ključne besede: arhitektura klicnega strežnika, omrežja naslednje generacije (NGN), IP multimedijski podsistem (IMS).

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1 Introduction

In the face of the new era in telecommunications, the concept of the next generation networks (NGN) has been alive for several years now. The concept that initially started as a universal system specification [1], [3], [10], has gained momentum when feasible technologies have emerged as proven enablers of new communications domain. Some years of testing have brought forth first experiences and identified technologies and methods, best suited to provide anticipated network and service convergence. Some most important forums and organizations in this respect are International Packet Communications Consortium (IPCC), Multiservice Switching Forum (MSF), ETSI Telecommunications and Internet converged Services and Protocols for Advanced Networking (ETSI TISPAN) and IETF SIP working group. As a result, several concepts and reference solutions have followed, e.g. VoIP (*Voice over IP*) [7], [9], ToIP (*Telephony over IP*), MSF Architecture [10], FMC (*Fixed-Mobile Convergence*) [6], [8], that reflected contemporary research and development trends in different fields of telecommunications systems and applied latest technologies available. The latest standardized and foremost widely accepted reference solutions are 3GPP IMS (*IP Multimedia Subsystem*) [4] and ETSI TISPAN NGN [5].

The IP Multimedia Subsystem represents a standardized conjunction of new generation paradigms, Internet technologies and proven multimedia technologies to establish an overlay global open standardized service delivery platform that enables provisioning of possibly converged multimedia services by combining legacy and new mobile and fixed networks in a user centric approach. Characterized by its mobile origin it urged for further expansions to address fixed domain as well. This has been completed within ETSI TISPAN NGN architecture that represents a broader architectural concept based on a subsystem approach that encompasses IMS as a core subsystem and addresses also wider system aspects such as access control issues, legacy services emulation and simulation, streaming and multimedia, etc. The two standards have gradually converged and today they represent joint reference architecture to provide access agnostic multimedia service environment.

1.1 From NGN to IMS

NGN network architecture typically encompasses the following multifunctional elements: softswitch, application server, media server and different types of media and signalling gateways.

There is no clear pathway or a demarcation point how and when a system is fully migrated from NGN to IMS. Therefore, it is of great importance to plan a well defined migration strategy since it affects nearly all system segments and network elements.

When discussing possible scenarios, several substantial network changes should be pointed out. In IMS session control functionalities are clearly separated from media and signalling which enables the core system to be entirely IMS-oriented while legacy segments are driven further to the edges. The application environment is separated from session control using standardized open interface technologies and designated functional entities to provide appropriate interconnection (SIP-based interfaces and service coordination functionality). Subscriber and application data are separated from service logic and service features. This altogether enables establishment of an independent application environment that supports rapid service development and deployment and openness towards the third party service, application and content providers. Moreover, such clear and open but standardized application environment separation brings forth access agnosticism which enables user mobility and hybrid network solutions.

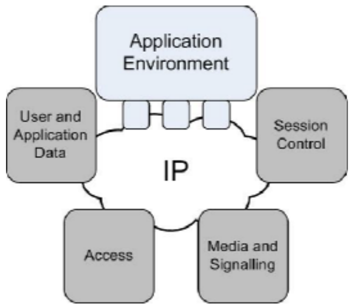

Figure 1: Functional separation of the next generation system in migration towards IMS.

A system is migrated from NGN to IMS when NGN network elements are modularly decomposed and the following logical entities can be clearly identified: CSCF (*Call Session Control Function*), AS (*Application Server*) and HSS (*Home Subscriber Server*).

An evident demarcation of a migrated system can also be identified in terms of core protocols. IMS defines IETF Internet-oriented protocols for core signaling solution. Session-based control and service communications should be based (strictly) on the SIP protocol that becomes the prevalent technology within such an environment. Communications between entities that handle user data and core session/service entities should be provided based on the Diameter protocol. Some additional protocol options are also possible with regard to legacy interconnection issues or legacy equipment reuse (e.g. H.323, MGCP etc.).

Regardless of the evolution stage, there are core network functions that need to be provided in all reference solutions in a form, specific to given technologies and concepts, and presented in corresponding network elements. One such network element that has undergone several migration steps and concept remodelling is softswitch [2]. In this paper we present a general migration scenario, addressing key issues regarding softswitch architecture with respect to NGN to IMS system transformation.

The remaining of this paper is organised as follows. We present a brief overview of general softswitch as a logical component composition in Section 2. Migration scenario in three steps is presented in Section 3 and commented and key issues are addressed. Conclusions of this paper are presented in Section 4.

2 Softswitch model

Softswitch is a core call control, signalling and service coordination component that represents several key functionalities of any form of the next generation system [2], [11].

Throughout the system transformation in pursuit of the next generation concept the general softswitch architecture has been modified towards a distributed and modular structure in two larger stages as shown in Figure 2.

Softswitch in the NGN environment can be understood as a standardized software implementation of central office functions that provide session control, service provisioning, interworking towards other environments and OSS&BSS functionalities. Common to merely all NGN solutions, it represents a compound of H.323 gatekeeper, media gateway controller, call agent and/or SIP server/client entity.

In an IMS environment, these functions are further distributed in a modular way between several logical entities, each of them representing a part of softswitch or a standalone element. Along with functional decomposition system protocols and procedures have changed during transformation from NGN towards IMS as well. Implementation of SIP and Diameter as standardized signalling protocols for communication between system entities brings forth remodelling of entire system orchestration and capabilities of each entity in its own. The SIP segment is clearly emphasised.

Such architectural decomposition has brought softswitch providers to a crossroad. Since softswitch as a compact element no longer exists in IMS, it is of the developer's choice to define functionalities that should be implemented within IMS softswitch, its internal architecture and modules it encompasses. As a result many definitions of IMS softswitch as a product are present in the telecommunications domain at the moment. Two of them are prevalent and in fact represent two separate and functionally different elements of a new generation network.

The first option anticipates unchanged internal NGN softswitch architecture, typically based on protocols H.323, Megaco/H.248, MGCP and/or SIP. This element is moved from the core to the edge position in the network and accordingly assumes network functionalities provided for interconnection to other (usually PSTN/ISDN) environments. In this case internal infrastructure as well as overall functional design of such element remain unchanged, the element is further equipped with appropriate interfaces that are required by the IMS infrastructure (e.g. SIP interface towards core IMS entities). Core network intelligence is no longer contained inside such element which poses a potential threat of becoming an edge interworking provider to a vendor.

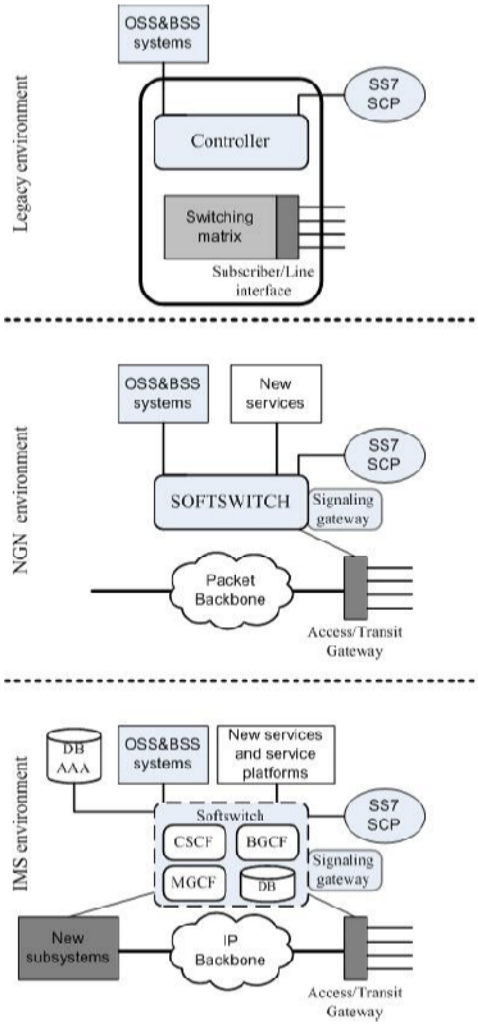

Figure 2: Evolution of softswitch architecture from the central office through NGN softswitch towards IMS softswitch.

Therefore it is of interest to softswitch providers to engage in the softswitch migration process in order to retain core intelligence in the product as well as to follow new technologies and concepts of modern communications paradigms of new generation IMS environments. The second option anticipates softswitch upgrade and considerable internal softswitch architecture modifications in order to pursue highly efficient modular flexible SIP-based platform that meets the IMS concept.

3 Softswitch migration proposal

In this paper we examine the second option from an alternative point of view, common to smaller or medium central office and/or softswitch providers that have legacy investments in rather proprietary solutions in the non- and pre-NGN stage of network maturity. The proposal results from a close cooperation between our research team and a Slovenian softswitch vendor to determine a reasonable migration process for their product. Nevertheless this is a vendor independent and general proposal that could be applied to several different initial infrastructure options and could be found interesting to those vendors that originate from traditional telecommunications and have gradually upgraded circuit-switched central office architecture towards NGN softswitch. Some most common steps in the scenarios are presented further in this section.

3.1 Step 1: Initial softswitch architecture

Original softswitch architecture, depicted in Figure 3, is originated from a traditional circuit-switched class 5 central office. Core intelligence is encompassed in a generic call control module (GCC). Service logic, local user database and support functions are an integral part of the core control application and are therefore functionally fully dependent on the GCC structure and mode of operation. There are some beginnings of access agnosticism, the platform provides termination for several different access technologies. Nevertheless in this case only access termination is provided, end users are treated equally in terms of system capabilities and service functionalities.

Such softswitch structure, directly derived from classical circuit-switched central office application structure, provides uniform user and service provisioning and therefore limits several advantages, offered by different technologies if used independently. From the SIP environment point of view innovative multimedia services, e.g. presence, push to talk, universal messaging, are not possible.

3.2 Step 2: Separating SIP

To gradually eliminate the deficiencies presented with a moderately upgraded CO platform, technologies should be separated and additional functionalities implemented for different technologies in use.

In pursuing the IMS concept, we introduced SIP domain separation from the remaining of the softswitch call control logic. In this case, SIP signaling is separated from other types of signaling and processed in an independent module. As shown in Figure 3, access signaling control routes user originated requests to the appropriate module: if the request type is SIP, signaling is routed to the SIP server, otherwise signaling is routed to the generic call control. For the purpose of enhanced user termination, H.323 and H.248 server modules could also be introduced to provide access-related functionalities in addition to existent telephone call control logic (e.g. terminal equipment configuration, authentication procedures, etc.).

Since this is an early migration stage, the implemented interface and communication methods between GCC and SIP modules are expected to be proprietary. Nevertheless it is advisable to implement standardized interfaces to meet future module requirements for open connectivity inside an IMS domain.

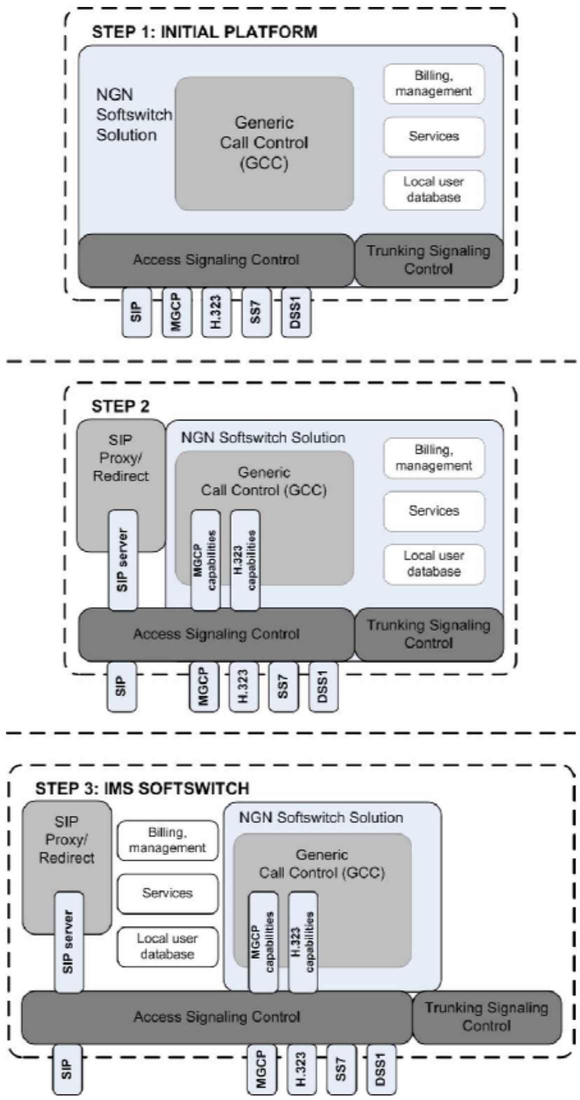

Figure 3: Softswitch migration proposal.

Connectivity between the SIP domain and other telecommunications domains (traditional or NGN) in this case could be achieved through GCC. When using GCC as a gateway towards outer world, it is important to bear in mind, that functionalities available to SIP users can be further diminished since the communication is handled in a manner equal to any other communication of NGN or circuit-switched type.

3.3 Step 3: Separating services, user database and support functions

From the SIP/IMS point of view, step 2 solution could provide basic connectivity with other SIP/IMS domains via SIP proxy/redirect server. Any other enhanced services provisioning is limited due to the fact that service logic, user database and support functions for SIP domain still reside inside the platform. Portfolio is therefore limited to basic telephony services common to classical service concept of a circuit-switched CO. Implementation of additional service logic in this case is barely possible due to limitations presented by circuit-switched concept that is still the base inside the GCC.

In order to pursue IMS concept consistency functions in question must be implemented separately. But to retain the existent structure, this proposal presents an architecture where the functions remain part of the softswitch architecture but are implemented modularly enough to allow adoptions for both classical and SIP domain. Furthermore, modularity prepares architecture for further IMS developments and final separation.

There are several issues when considering the implementation of services, user database and other support functions modularly because they should interoperate with both legacy and NGN/IMS environment in parallel. Mode of accessibility and outward functional and data organization are most important to ensure complete interworking with system entities that use these capabilities while providing services. Other option is to provide all these functionalities for SIP domain externally in an independent way, while internal service, user database and support modules only serve to NGN and legacy sections of the solution. This second option brings poorer legacy investment exploitation but it represents a step closer to IMS concept in general.

3.4 Extended IMS softswitch

The final migrated softswitch solution in part represents several core entities of a basic IMS environment. Its structure is presented in Figure 4.

SIP server engages call session control functions (CSCF) and service triggering while generic call control with all additional capabilities enables functions that provide interconnection with other legacy and NGN domains (gateway controllers and gateways). Corresponding protocols and interfaces should be implemented. IMS section requires standardized extended SIP and Diameter reference points to provide communication between SIP server, HSS, AS and directly connected SIP users. Also standardized interconnection towards other IMS systems should be provided via appropriate SIP-based interfaces (possibly through additional gateways). Other types of interfaces are also required depending on the types of protocols used in legacy and NGN segment of the softswitch as well as within interconnections towards other network elements, support systems and legacy and NGN environments (e.g. H.323, SS7, MGCP, Megaco/H.248, Radius, MAP, etc.).

Several issues within such an extended IMS softswitch should be discussed. There is a direct mapping between capabilities of support modules and standalone IMS entities that could be duplicated and could cause inconsistencies if not managed properly.

In the IMS environment, HSS is provided as a central user database and extended authentication, authorization and accounting server. Therefore a question arises how to maintain user data inside internal data module and to what extent should this module be in use and synchronized for SIP users. Three possibilities are at hand, should the user data be handled only by HSS, only internally by a softswitch solution or synchronized in a shared solution.

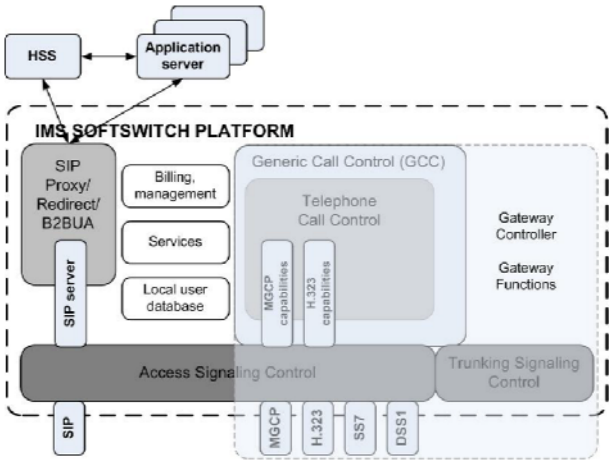

Figure 4: Migrated softswitch architecture as an extended IMS element.

Services in this case could also be provided in more ways. One option is to retain internal service module and extend it to provide services for SIP users in addition to legacy and NGN users. This option could be interesting if planned service portfolio is limited to standard telephony services that could be used commonly in legacy and NGN/IMS domains. The second option pursues IMS concept and introduces independent and possibly dedicated application servers that provide in coordinated cooperation some form of service delivery platform and openness towards third party providers. The third and most expected option is a form of combined service provisioning, partly with standalone dedicated application servers for advanced multimedia services, and with a local application server implemented internally in IMS softswitch to provide basic telephony oriented services.

Some further issues should be addressed when discussing migrated softswitch architecture to fully meet IMS concepts as well as general telecommunications networks principles that this paper does not present, such as lawful intercept, ensuring entire range of legacy telecommunications services, session border control, overall system management options with regard to tightly coupled legacy management solutions, etc. There are not IMS standardization or softswitch providers that have yet met these issues.

4 Conclusion

In the prospects of system migration towards IMS concept, softswitch providers are faced with challenging issues regarding architecture modifications and product portfolio renewal with respect to partial retention of the existent solutions. In this paper, we present a possible softswitch migration scenario where multiple protocol environments are established in parallel inside one solution that offers a higher level of modularity and openness. According to the user type, only appropriate protocol entities are engaged and therefore more protocol specific capabilities could be implemented and provided to the user. The architecture anticipates clear SIP segment separation which provides for faster and simpler final migration in the context of IMS. Key issues are addressed and a general migration scenario is presented that can be mapped to several different infrastructure options for CO and softswitch providers in both fixed and mobile telecommunications domains.

5 Acknowledgement

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