Next Generation Network Service Architecture in the IP Multimedia Subsystem

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Abstract
The objective of this research work is to provide the IP Multimedia Subsystem of UMTS with a SIP-based mechanism for managing the interaction, composition and reuse of a limited number of standardized Service Capabilities in order to develop the Next Generation Network (NGN) services. The service invocation mechanism that we propose in this paper is extensible to deal with the interaction and composition management of a wide range of NGN services.

Key Words: Service Capability Interaction Management, Service Architecture, SIP, IMS, NGN.

1 Introduction

NGN supports a wide range of services varying from real time and interactive multimedia services (audio & video telephony, conferencing, Instant Messaging, Presence and Location based services) to non-interactive (multimedia streaming and Push services) and web (e-commerce, e-learning, and e-medicine) services.

The convergence of the "*vertically integrated networks*" (where for each kind of services (data, audio and video) a specific network is considered) to a "*horizontally integrated network*" that offers a unique network infrastructure is one of the foremost advantages brought by NGN [9]. The principles, characteristics and issues of NGN are studied in [12, 13 and 14].

The 3GPP (3rd Generation Partnership Project) open IP-based infrastructure, IP Multimedia Subsystem (IMS) [1], that uses Session Initiation Protocol (SIP) [6] as signalling protocol, is an emerging but recognized standardization effort for supporting the service convergence over the heterogeneous networks.

Realizing the service convergence paradigm by IMS enables service providers to offer enhanced NGN services to their users.

As presented in figure 1, IMS contains a horizontally integrated service architecture where the service and control layers are separated.

Besides, one of the goals of IMS is to design its service layer in a way of enabling the creation of innovative services by integrating existing service building blocks. In other words, IMS offers the elementary and standardized service building blocks that can be reused by different application servers to enrich their services. Sharing these service building blocks reduces the time-to-market of services.

However enabling this reuse and share of the service building blocks by application servers and managing the integration and composition of these service building blocks necessitates the introduction of a service composition and interaction manager mechanism.

In this paper we propose a service invocation mechanism that ensures the development of NGN services in IMS by enabling the integration of different service building blocks. Furthermore, we present in detail the functional and architectural aspects of this proposition and we discuss about the requirements and the technical approaches proposed for developing the NGN services.

The rest of this paper is structured as follows:

In the next section, after outlining standardized service invocation mechanism in IMS, we present our proposed IMS service invocation mechanism that is based on the introduction of a service controller between the session control and the service layer of IMS.

The introduction of this service controller necessitates precise functional and architectural considerations. We highlight the functional aspects of our proposal in this section.

Section 3 gives an overview of the architectural aspects including the mechanisms to be defined for the service controller in order to control the access to the service building blocks and to manage the integration of the services.

A use case, of our proposition is presented in section 4. Finally we conclude this paper by presenting the advantages of the proposed service invocation mechanism and discussing about the reaming development issues of the NGN services in IMS.

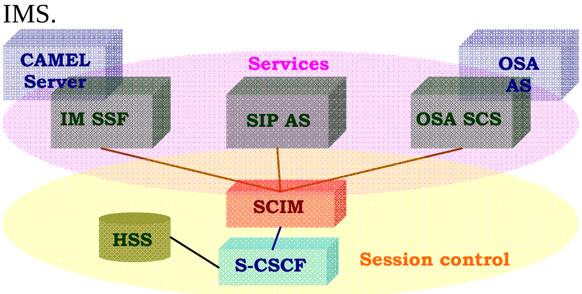

Figure 1: The Horizontally Integrated Architecture of IMS

2 Service Invocation in IMS

In this section after explaining the already specified service invocation mechanism in IMS, we introduce our proposed service invocation mechanism and we present the functional aspects of this proposal.

2.1 3GPP Service Invocation Mechanism

In IMS, as presented in figure 1, services are invoked through a SIP server in the session control layer called: Serving Call Session Control Function (S-CSCF). S-CSCF is the functional entity of IMS that performs the session control and service triggering.

IMS services may be hosted by SIP Application Servers (AS), Open Service Access (OSA) AS (through OSA-Service Capability Server (OSA-SCS)) and CAMEL servers (Customized Application for the Mobile network Enhanced Logic) (through IP Multimedia Service Switching Function (IM-SSF)).

All of the three types of the AS hosted in the service layer of IMS (SIP AS, OSA SCS and IM-SSF) behave as SIP AS over the SIP-based interface ISC (IP Multimedia Service Control) and S-CSCF invokes them without disposing any functional description of these ASs: S-CSCF knows ASs only by their names/addresses.

This AS invocation, performed through ISC, is based on the user profile retrieved from the Home Subscriber Server (HSS). User profile contains the conditions (initial Filter Criteria: iFC) indicating to S-CSCF when and which AS has to be invoked (depending on the information carried in the method, headers, URI … of the incoming SIP request). S-CSCF invokes the service by forwarding the SIP request to the corresponding AS.

2.2 Proposed Service Invocation Mechanism

Figure 2 illustrates the functional vision of our proposition, where we define a boundary between the Network Operator (NO) domain and the third party Service Provider(s) (SP) domain(s).

Based on this proposition different service providers share and reuse the service building blocks of the network operator in order to enrich their services.

3GPP uses the term of “Service Capability” (SC) for referring to these modular and self contained service building blocks.

Presence [4] and Messaging [5] are two examples of Service Capabilities that can be reused in the creation of integrated service such as voicemail.

On the one hand, reusing Service Capabilities enables network operators to offer a multitude of unique services with rich personalisation possibilities to their users (depending on the schedule, preferences, terminal capabilities, location and presence information of the user) and on the other hand it offers service providers the possibility of implementing rich services.

However even if Service Capabilities are relatively stable and that their implementation obey the standard specifications, providing the possibility of reusing Service Capabilities of IMS for offering enriched services to users reclaims precise service interaction management.

Although Open Service Access (OSA) [3] provides the glue between services by means of open standardized Application Programming Interfaces, it can not be regarded as an optimal answer to the service interaction management needs in IMS, while, OSA has not be developed specifically for IMS and therefore “adapting” OSA to IMS will lead to complex and costly solutions that can be simplified out of OSA scope.

Hence, In order to deal with this issue, we propose a service composition management mechanism that is an alternative to the already existing IT based mechanisms. This management consists of controlling the access of different Application Server(s) to the Service Capabilities and preventing the violation of the confidentiality of the user information. Contrary to the existing mechanisms, our proposition is SIP based and adaptable for IMS.

In this proposition we enable IMS with a SIP-based service composition manager by using the SIP AS Service Capability Interaction Manager (SCIM) of IMS (illustrated in figure 1).

SCIM is initially introduced by 3GPP for managing the interactions between application servers. But the service interaction management functionalities of SCIM are not specified.

We propose to use the SIP AS SCIM for managing the interaction between services in order to ensure the coherency of our proposed SIP-based service composition management with the SIP-based service invocation mechanism of IMS.

As presented in figure 1, we consider SCIM as an entity between the session control layer and the service layer of IMS that provides among other functionalities [10,11] a uniform Service Capability access mechanism for AS(s).

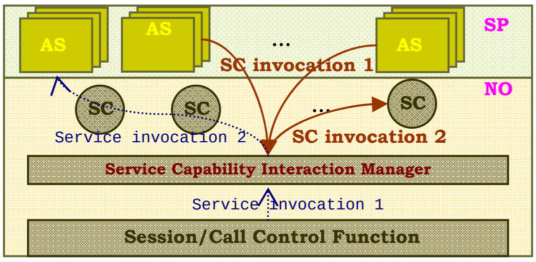

Figure 2: Proposed Service Invocation Mechanism

3 Architectural and Technical Aspects of the Proposed Service Invocation Mechanism

The introduction of SCIM between the session control layer and the service layer requires the definition of a relation model between SCIM and its surrounding entities.

In this section we will first discuss about the constraints for defining this relation model and then we present the technical approaches of this relation model by indicating the exact proposed mechanisms.

3.1 Architectural Aspects

Defining a model that presents the relation of SCIM with its surrounding entities i.e. S-CSCF, AS/SC and HSS is faced to the following two constraints:

3.1.1 Constraints for defining the relation model of SCIM:

I. S-CSCF needs the address of SCIM:

When S-CSCF receives an initial request, it checks iFCs (presented in figure 4) in the order given by their priorities. If the Trigger Point of an iFC is met, the corresponding AS will be invoked.

According to the specifications, S-CSCF should forward the request to the AS and waits for an answer. But as in this proposition we add SCIM in the service invocation path, the request must be first forwarded to SCIM. Hence, the address of SCIM must be available for S-CSCF.

II. SCIM needs the service composition information for controlling SC access:

Using a SC by a service must be based on the agreement performed between the network operator and the service provider. This agreement indicates the necessary information that SCIM needs for managing the service composition. Hence, SCIM as an intermediate between Application Server and Service Capability must be provided with this service composition information.

3.1.2 Solution for defining the relation model of SCIM:

One possible solution to the first issue is to associate one SCIM to one S-CSCF. Therefore, once S-CSCF needs to invoke an AS according to the service profile of the user, it forwards the incoming request to AS by passing it through the known SCIM.

According to this solution, the service composition information related to each AS to be invoked from one S-CSCF, will be saved over the SCIM associated to the S-CSCF. Therefore the service composition information of *one* AS may be available over *many* SCIMs (each SCIM that invokes the AS will contain this information) resulting redundancy of the service composition information over multiple SCIMs.

In order to prevent the dispersion of service composition information all over the network, we propose to associate one SCIM to one (or more) AS(s). Based on this proposition, each AS has one unique SCIM that could "serve it". Therefore all the requests destined to this AS from any S-CSCF passes through this unique SCIM. This association is presented in the diagram of figure 3:

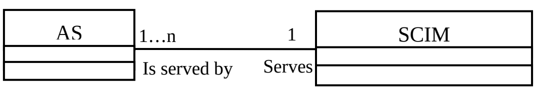

Figure 3: Proposed AS-SCIM Association

However, this association doesn't solve the problem of SCIM address availability to S-CSCF. This issue can be resolved by providing HSS with a dynamic AS-SCIM association. Although this proposition ensures the service availability; but enabling such a dynamic SCIM discovery procedure is very complex, costly and heavy to manage. Moreover introducing a supplementary transaction (SCIM/HSS interface) for SCIM address discovery at each AS invocation request; increases the service invocation process time.

Therefore faced to the compromises regarding in the one hand the *service availability* and on the other hand the *service invocation time-span*, we have more preferences to focus on the time constraints rather than ensuring the dynamic service availability.

Based on this preference we propose the following modifications to the current service invocation mechanism of IMS in order to provide the address of SCIM to S-CSCF:

1. Modifying the content of iFC (illustrated in figure 4):

The Application Server class of iFC contains zero or one instance of the Service Information class that is initially defined to enable the transparent information transferring to AS. We propose to use the "Service Information" class to indicate the AS to be invoked and the "Application Service" class to indicate the SCIM associated to this AS.

Therefore the address of SCIM is given to S-CSCF at the same time that the name/address of AS (i.e. at the user profile retrieving phase).

2. Introducing the supplementary routing functionalities over S-CSCF in order to route the message first to SCIM and then to AS.

Following to the proposed SCIM-AS association, the second constraint (i.e. defining the service composition information format and providing SCIM with this information) can be resolved by introducing an "**Application Server – User**" analogy.

In other words, as in the case of user subscription procedure to IMS a *user profile* is created and saved in HSS [2], we propose that the Application Server subscription to the use of one or more Service Capabilities be represented by a template called: *Service Capability Profile (SCP).*

This analogy is interpreted as following:

- ***User** subscribes for using an **Application Server**, <u>as</u> **Application Server** subscribes for using a **Service Capability**.*
- *User services are invoked based on the initial Filter Criteria (**iFC**) defined in the service profile of the user, <u>as</u> Service Capabilities are invoked based on the Service Capability Criteria (**SCC**) defined in the Service Capability Profile of an Application Server.*

• *User access to an Application Server is controlled in* ***iFC****,* as *Application Server access to a Service Capability is controlled in* ***SCC****.*
• *One* ***S-CSCF*** *is associated to one* ***user*** *and contains the service profile of the user,* as *one* ***SCIM*** *is associated to one* ***Application Server*** *and contains the Service Capability Profile of the Application Server.*
• ***S-CSCF*** *enables the access of the user to Application Server,* as ***SCIM*** *that enable the access of the Application Server to Service Capability.*

This analogy is illustrated in the UML diagrams of the figures 4 and 5:

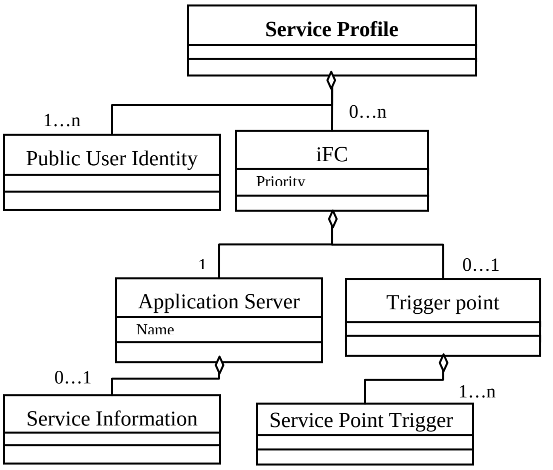

Figure 4: IMS user Service Profile defined by 3GPP

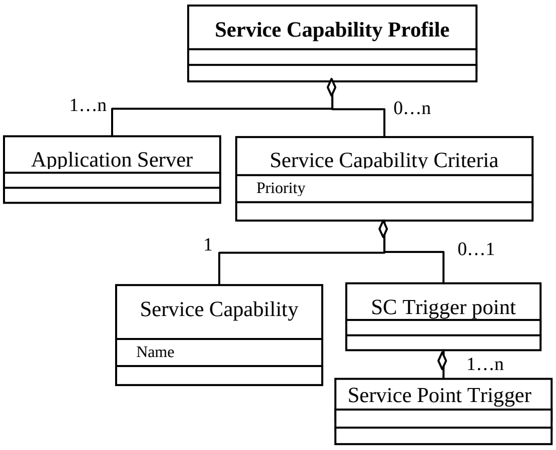

Figure 5: Proposed Service Capability Profile of AS

At the service provisioning time, the network operator may whether store the service capability profile of an AS over the SCIM associated to this AS, or it may use the central data base of IMS, i.e. HSS, for storing this information.
Alongside with the proposed analogy between the service profile of an IMS subscriber (stored in HSS and retrieved by S-CSCF at the user registration time), and the service capability profile of an AS, we propose to store the service capability profile in HSS.

Then, once an AS is to be invoked, the SCIM associated to AS, retrieves the service capability profile of AS from HSS and stores it. This information will be used not only for service composition management of AS during the current session; but also subsequent sessions; as long as SCP related to this AS remains in the SCIM.
This solution brings the following modification to the actual IMS service invocation platform:
1) Defining SCP in HSS (at service definition time)
2) Defining the SCIM/HSS interface for SCP retrieving at the “first” AS invocation request (Sh interface can be applied)
3) Modifying the iFC as explained in 3.1.2 in order to include SCIM in the route from S-CSCF to AS
4) Modifying the S-CSCF service invocation mechanism by adding SCIM on the service path and introducing the supplementary routing functionalities over S-CSCF for routing the message first to SCIM and then to AS
5) Creating SCIM as a SIP AS performing the controls detailed in the next section

3.2 Technical Aspects

In Figure 6 we present step by step the control procedures that must be performed in order to enable the management of the use of SC1 by AS1.

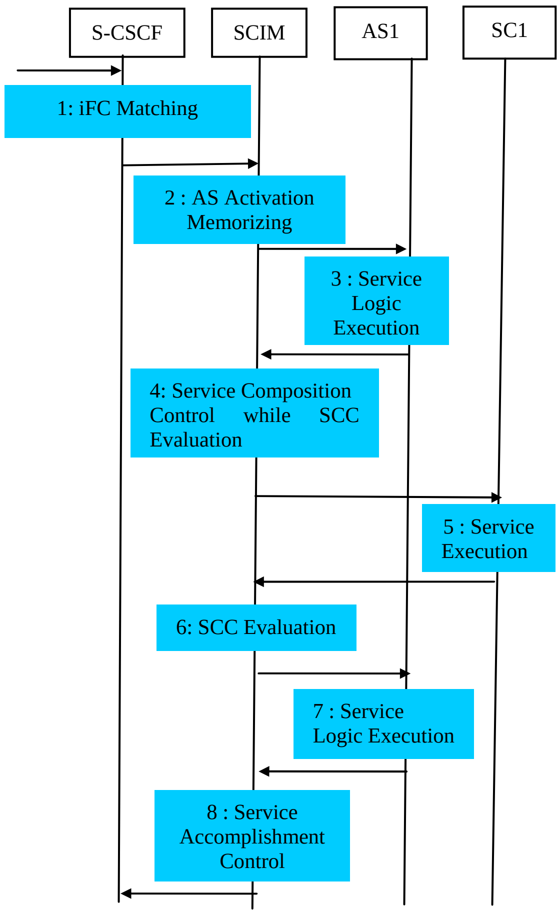

Figure 6: Controlling the Service Capability Composition

1. iFC Matching

On the reception of an initial SIP request, S-CSCF checks the iFCs one by one (based on their priorities) and once an iFC is matched (and that an AS must be invoked), S-CSCF forwards the SIP request to the SCIM associated to the AS to be invoked mentioned in the Application Server element of the iFC.

2. AS Activation Memorizing

By the "first" AS invocation request, SCIM retrieves the SCP related to the AS from HSS. (This information may already be available over SCIM, if the AS has been previously invoked by SCIM). Afterwards, SCIM memorizes that the AS is being activated to the Public User Identity (mentioned in the incoming SIP request). Then SCIM forwards the SIP request to the related AS.

3. Service Logic Execution

AS executes its service logic and recognizes that for continuing the execution it needs to contact a SC. From a SIP point of view AS may contact an SC in one of the two following ways:

I. AS constructs a new SIP request that either creates a new SIP dialog with SC (e.g. SIP SUBSCRIBE request [7]), or a request being part of an existing dialog or finally of a standalone transaction (e.g. SIP MESSAGE request [8]).

II. AS simply forwards the initial received SIP request to the SC.

4. Service Composition Control while Service Capability Criteria (SCC) Evaluation

When SCIM receives the request from AS, based on the information memorized in step 2, it checks if the AS has already been activated for the concerned public user identity or not. If not, the access to the service will be denied and SCIM sends an error message.

If this check is passed, SCIM evaluates the SCC related to the AS in order to find out based on the received request which SC should be invoked. Then, SCIM forwards the request to the SC indicated in the SCC.

As multiple AS(s) may share one SC, SC should be aware by which AS the SC invocation is asked, while in some cases we need different information to be delivered depending on the AS. In other words, without indicating the address of AS to SC, SC behaviour will be the same for any AS.

In our platform we consider that SC will be aware of the address of AS based on the address of AS that is indicated in the "From" header field of the SIP message sent from AS to SCIM.

5. Service Capability Execution

The SC executes its service and based on its behaviour answers to the SIP message:

- If SC acts as Proxy server, it sends the same message back to SCIM.
- If SC acts as Terminating User Agent, it finishes the incoming request by a final response.
- If SC acts as Back to Back User Agent, it finishes the incoming request by a final response and creates a new request.

6. Service Capability Criteria (SCC) Evaluation

Respecting the proposed SCC–iFC analogy, SCIM continues the SCC evaluation (on the reception of the SIP message from SC) in order to invoke other SCs if needed. Once all the SCCs are evaluated, the request is sent back to the AS. As SCIM and SC are in the same operator's domain (i.e. SC is a trusted entity and is supposed to behave correctly) SCIM will not control the interactions from SC to AS.

7. Service Logic Execution

Based on the service logic in AS, whether it requests the invocation of another SC (repeating from step 4) or terminates its service execution.

8. Service Accomplishment Control

Based on the received message from AS, SCIM verifies the SCC and recognizes that SC invocation is terminated and therefore it sends the message back to S-CSCF.

4 Use Case

In this section we present an example in which a Presence (PS) service capability is reused by a Chatting (Chat) and a Conferencing (Conf) application server.

In figure 7, we suppose that: User B is in chat list and conference list of user A; A invites B to a conference, but B is not available for the conference; therefore A invites B to a chat. The description of each step is as follows:

1. A invites B to a conference.

2. S-CSCF receives an initial request (Invite) and after iFC evaluation it recognizes that the Conference Server (Conf) must be invoked. S-CSCF forwards the request to the SCIM associated to Conf indicated in the Application Server class of iFC.

3. SCIM memorizes that Conf is being activated for the public user identity of A. Then SCIM retrieves the SCP related to Conf from HSS (if not already locally available), and forwards the request to Conf.

4. Conf performs its service logic and recognizes that for continuing the execution it needs to contact PS. Conf constructs a Subscribe request in order to get the presence information of B, sends the request to SCIM and waits for the answer.

5. When SCIM receives the request, it controls if Conf has already been activated for A or not. If the check is passed, SCIM evaluates the SCC and recognizes that it has to forward the request to PS.

6-7. PS executes its service logic and terminates the Subscribe request by a 200 OK response that will follow the request path i.e. SCIM and Conf.

8. Also PS creates a Notify request that contains the presence information of B in the body part. This information is related to the Conf address that SCIM had supplied in the incoming Subscribe request to PS.

9. On the reception of the answer (Notify) from PS, SCIM continues the SCC evaluation in order to invoke other SCs if needed. In this example we suppose that no other SCs are to be invoked, therefore SCIM sends back the Notify to Conf.

10. Based on the service logic and the presence information of B, Conf recognizes that the service execution is accomplished. Hence it creates an appropriate answer (that terminates the Invite request received at step 3) and forwards it to SCIM. In this example, according to the presence information of B indicating “Don’t disturb” in the note element of the body part, Conf decides to abort the session and sends back an error final response (Busy).

11. SCIM receives SIP answer related to the first SIP Dialog (created by the initial Invite request) and forwards it to S-CSCF according to the Via header.

12. S-CSCF sends the request to A.

13. Now, A invites B to a chat.

14. S-CSCF evaluates the iFC and it recognizes that the Chat AS must be invoked. S-CSCF retrieves the address of the SCIM associated to Chat from HSS and forwards the request to the discovered SCIM. (We suppose that same SCIM is serving Conf and Chat servers).

15. SCIM memorizes that Chat is being activated for the public user identity of A. Then it retrieves the SCP related to Chat from HSS (if not already locally available) and forwards the request to Chat.

16. Chat performs its service logic and recognizes that for continuing the execution it needs to contact PS. The Chat server constructs a Subscribe request in order to get the presence information of B. Then it sends the request to SCIM and waits for the answer.

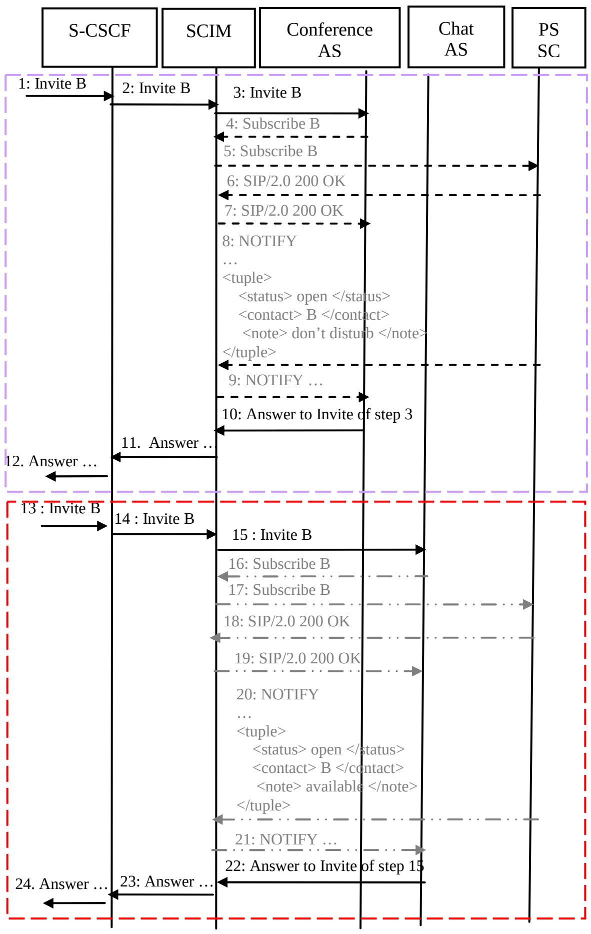

Figure 7: Presence Service Capability shared in Chatting and Conferencing application servers

17. When SCIM receives the request, it controls if Chat has already been activated for A or not. If the check is passed, SCIM evaluates the SCC and recognizes that it has to forward the request to PS.

18-19. PS executes its service logic and terminates the Subscribe request by a 200 OK response that will follow the request path i.e. SCIM and Chat available in the Via header.

20. Also PS creates a Notify request that contains the presence information of B in the body part indicating that B is “available” for Chat.

21. On the reception of the answer (Notify) from PS, SCIM continues the SCC evaluation in order to invoke other SCs if needed. In this example we suppose that no other SCs are to be invoked, therefore it sends back the answer to Chat.

22. Based on the presence information of B, Chat accomplishes the service execution and hence it creates an appropriate answer (that terminates the Invite request received at step 15) and forwards it to SCIM. In this example that B is “available” for chat, this later sends back the Invite request to the SCIM.

23. SCIM evaluated the SCC and recognizes that the request doesn't require any SC invocation and that it must therefore be forwarded to S-CSCF.

24. S-CSCF sends the request to A.

5 Conclusion

In this paper we have proposed improvements to the actual service invocation mechanism of IMS. This proposition brings new insights to the NGN service capability integration mechanisms in IMS:

- The Service Capability Profile that we defined for each application server resolves the foremost service composition issues that are:
    i. How to bind multiple Service Capabilities to an AS
    ii. How to provide a Service Capability for an AS
- Moreover as presented in the use case, this proposed service invocation mechanism enables the invocation orchestration of a wide range of NGN services.
- Finally the proposed mechanism can be considered as a pioneer step towards the realization of NGN service convergence using SIP based solutions instead of IT based ones. However, these two approaches will need to be analysed and compared in further studies.

By taking the advantage of the proposed service invocation mechanism and based on the architectural and technical issues discussed in this paper, in the next step of our work, we will focus on the implementation and development of this service invocation mechanism over IMS.
Moreover we will extend our mechanism to enable a dynamic service capability discovery by concentrating on a more extended range of service capabilities including mobility manager, terminal capability manager, and location manager.

6 References

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