

Service Concentration Node in Internet Multimedia Subsystem (IMS)

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Abstract. Convergence of the cellular world to an all-IP domain has stimulated the development of Internet Multimedia Subsystem (IMS) service architecture, which is touted by service providers and vendors as the next generation solution for breaking the barriers not only between cellular and IP worlds, but also between wireline and wireless networks. Although many GSM operators and legacy network service providers are adapting rapidly to the IMS world, the pace of this adaptation process is still quite low in certain parts of the world. In this paper, we propose a novel IMS concept referred to as Service Concentration Node (SCN), which enables the operators to provide their customers with IMS services that are offered in other domains with which the operator has a signed agreement, and thereby facilitates the utilization of a vast amount of IMS services in various operator networks. The formulated technical framework as well as its accompanying business model is quite promising in enriching the IMS services experience in next generation networks.

1 Introduction

We have witnessed a tremendous growth in various technologies such as WiFi, VoIP, enterprise IP, IP-TV, and WiMax, where IP is the common link shared between all of them. IMS architecture is envisaged to allow the true realization of convergence, by opening up doors for the operators to provide their subscriber base with the delivery of media rich services independent from the location of the user and the access technologies. The initial standard was originally defined by 3GPP [1][2][3][4]. ETSI TISPAN and the ITU are also working on the IMS architecture [5].

IMS service architecture is comprised of a layered system consisting of interoperable modular components, which enable the service providers to implement and manage new services in a rapid and efficient way. Doing so, it also eliminates the reliance on a single vendor for components. This service layer is built on top of the IMS Core Layer, which consists of Call Session Control Functionalities (CSCF's), namely P-CSCF (Proxy-CSCF), Serving-CSCF (S-CSCF), and Interrogating-CSCF (I-CSCF), as well as Breakout Gateway Control Functionality (BGCF) and Home Subscriber Server (HSS). In the current IMS architecture, the services of a user reside in the user's home network domain, communicating with the S-CSCF in

the user's home domain. Our proposed scheme enables the end user to utilize the IMS services offered in another IMS domain through the Service Concentration Node (SCN), which communicates with the user's S-CSCF in its home domain. Typically, the operator of the user's home network has a signed agreement with the IMS service providers communicating through the SCN. This way, the operators that currently lack the IMS services infrastructure are able to provide their customer base with enriched multimedia IMS services, such as Sponsored Call and Video RBT applications [6].

The rest of the paper is organized as follows: Section 2 provides a brief overview of the IMS architecture. Section 3 consists of the overall architecture and signaling flow of our proposed scheme, whereas Section 4 gives the detailed design of the SCN. Finally, Section 5 concludes the paper.

2 IMS Overview

3GPP defines IMS as a new subsystem consisting of a new mobile network infrastructure that enables the convergence of data, speech, and mobile network technology over an IP-based infrastructure. As depicted in Figure 1, the architecture can be considered to be consisting of 3 layers; namely IMS Services Layer, IMS Core Layer, and IMS Convergence Layer.

The top layer is the IMS Services Layer, where applications and service components reside. A multitude of services such as voice and video telephony, instant messaging, presence services, push to talk, etc. are delivered through the IMS interface to the IMS Core Layer, where session control is executed. The SIP Application Server (SIP-AS) is an IMS Application Server on which these IMS services are built. The application logic is written using the API's of SIP-AS, typically defined as JSR 116 [7]. There are key server components that help serve the multimedia content delivery, such as the Media Server, Streaming Server, Instant Messaging and Presence Server. The SIP-AS's communicate with the S-CSCF, which resides in the IMS Core Layer.

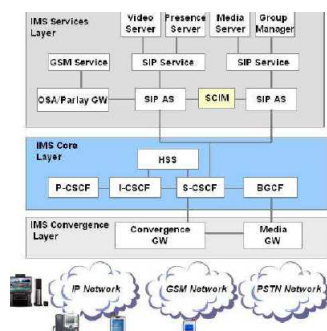


Fig. 1. IMS Architecture

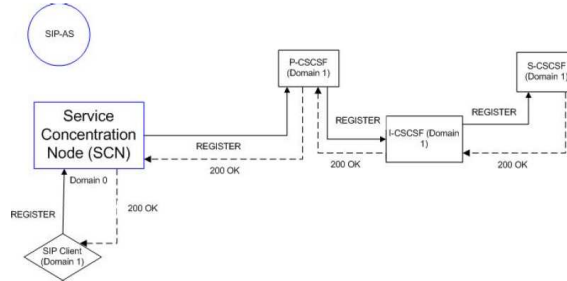


Fig. 2. Registration procedure in the proposed scheme

The middle layer is the IMS Core Layer, which consist of CSCF’s, HSS, and BGCF. CSCF’s are the functional areas within the IMS that provides all of the session and call control, helping set up, manage sessions and forward messages between IMS networks. It is the central routing engine and policy enforcement point for the network, and uses the SIP protocol for call control [8]. The CSCF is also broken out into three specialized functions known as the S-CSCF, I-CSCF, and P-CSCF. S-CSCF routes the SIP signaling to and from the subscribers via SIP-AS’s, in accordance with the service profile information held for each subscriber in the HSS. On the other hand, I-CSCF provides location services when a message or service must traverse multiple IMS domains, whereas P-CSCF handles all of the requests to and from the user and forwards them appropriately.

HSS is a centralized database that consists of all the pertinent user information, such as home network location, security information, and user profile information. The importance of HSS lies in the fact that it removes the burden of having to replicate this information for different services and different types of access networks. The S-CSCF and SIP-AS’s communicate with the HSS using Diameter protocol. S-CSCF extracts the service information of the user from HSS in the form of Initial Filter Criteria, which defines the trigger points for services and pointers to SIP-AS’s where the specific service application logic exists.

The bottom layer is the IMS Convergence Layer, which bridges the IMS and legacy networks and is comprised of three key components defined by IMS: Signaling Gateway, which translates between SIP and SS7 signaling, and Media Gateway, which translates between IP and the legacy transport network.

3 Service Concentration Node (SCN) Overview

Figure 2 illustrates the registration procedure in our proposed scheme. First of all, the operator of IMS domain-1 has an agreement with the operator of IMS domain-0, where the SCN and the AS’s of the offered IMS services reside. Domain-1 operator provides its customers with an SCN-enabled SIP client, which basically sends towards SCN the REGISTER request having the domain-1 URI. SCN keeps a list of the served domain names. Upon receipt of this REGISTER message, SCN checks whether this message is one of the served domains.

If yes, then it saves the location; i.e., URI-IP address mapping, of this user. Then it loads the Initial Filter Criteria (IFC) of this user. This way, the trigger points, namely where the IP addresses of the AS's of the services that this user has subscribed to reside, are loaded. Afterwards, without performing any authentication or location update procedure, SCN forwards this request to the P-CSCF of the home domain, which is domain-1. The REGISTER message is then passed towards the S-CSCF of the home domain, which performs the authentication procedure and then sends back an 200 OK message, after a possible 401 UNAUTHORIZED message. Note here that the authentication is done in the home domain, whereas the location saving and Initial Filter Criteria loading are implemented in SCN.

4 Service Concentration Node (SCN) Overview

The call flow initiated from an SCN-enabled subscriber is illustrated in Figure 3. Upon receiving the INVITE message, the SCN realizes that this user has a SIP application to be offered first. Therefore, the INVITE message is forwarded to the pertinent SIP-AS, the IP address of which was retrieved during loading of the Initial Filter Criteria. The SIP-AS implements its service logic; for instance, if this is a Sponsored Call application, it initiates another call to the Media Server, and after the media is played to the user, it tears up its new call with the Media Server, and then forwards the original INVITE message to the SCN [6]. If the SIP-AS is willing to stay on the path during the entire call flow, then it inserts its IP address to the Record-Route header of the INVITE message before forwarding it back to the SCN. Afterwards, SCN checks whether the destination domain of this INVITE message is one of the served domains. If yes, then it forwards this INVITE message to the pertinent domain. The normal SIP call flow then proceeds with 180 Ringing, 200 OK, and ACK messages.

On the other hand, the call flow initiated towards an SCN-enabled client is depicted in Figure 4. When the INVITE message is received, if the user has a terminating side service, like Video RBT [6], then the INVITE message is forwarded to the pertinent SIP-AS. Similar to the previous case, the SIP-AS

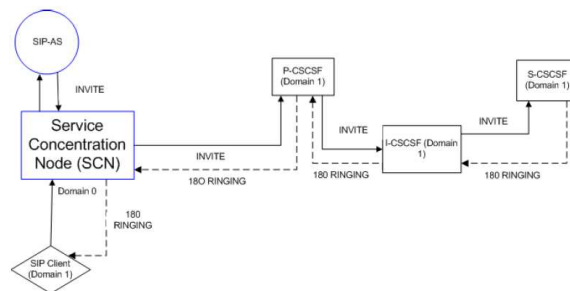


Fig. 3. Call flow initiated from an SCN-enabled client

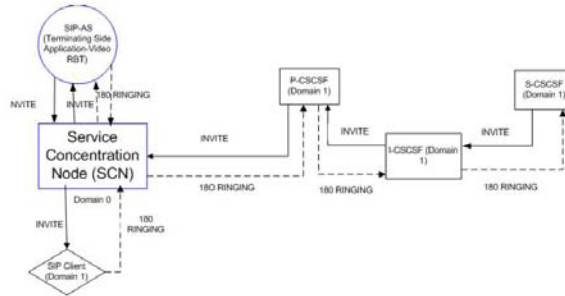


Fig. 4. Call flow terminated at the SCN-enabled client

may prefer to stay on the path during the entire flow (which is a must for Video-RBT application) by inserting a Record-Route header containing its own IP address to the INVITE message. Afterwards, the INVITE message is directly delivered to the location of the terminating user, which was saved during the registration process.

5 Detailed Design

Service Concentration Node (SCN) is implemented on top of the SIP-to-Mobile Gateway [9], where communication between software entities is accomplished via Messaging and Distribution Framework (MAD) [10]. The functionalities of the software entities in Figures 5 and 6 are as follows: SIP SIGNALING entity is responsible for SIP signaling, whereas SIP PROXY is the main call control module. SIP REGISTRAR performs the registration related functionalities and SUBSCRIBER MANAGER is responsible for maintaining the subscriber related information, such as saving the subscriber’s location in the database. SIP SIGNALING is written using C++, while all the rest are written in Java.

When a REGISTRATION message corresponding to domain-1 is received by SIP SIGNALING, it sends an equivalent MAD message; i.e., RegistrationReq Proxy. SIP PROXY realizes that this message corresponds to one of the served sip

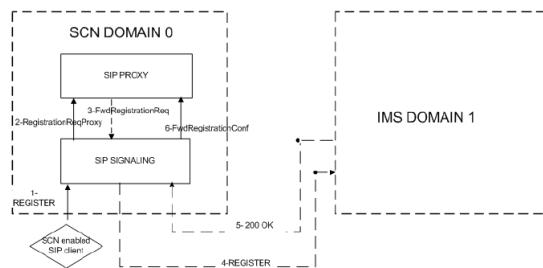


Fig. 5. Registration procedure phase 1

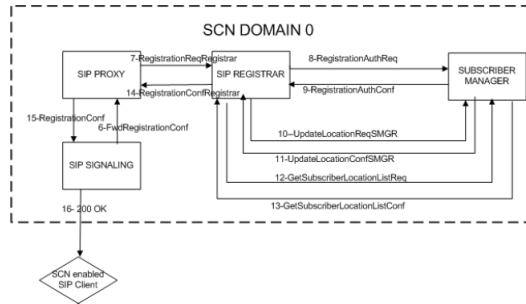


Fig. 6. Registration procedure phase 2

domains; therefore, it first loads the Initial Filter Criteria of this message, then basically forwards this message to the pertinent IMS domain. After 200 OK message is received from the IMS domain-1, SIP SIGNALING entity sends FwdRegistrationConf message to SIP PROXY. SIP PROXY is now aware of the fact that it has to save the location information of this user without performing any authentication procedure, because the user has already been authenticated in its home domain. Hence, it executes the sequence of messages depicted in Figure 6.

After receiving the FwdRegistrationConf message, SIP PROXY sends a RegistrationReq message to SIP REGISTRAR, which sends appropriate messages to SUBSCRIBER MANAGER such that the location; i.e., URI-IP address mapping, of the user is saved in the database. SIP REGISTRAR first sends a RegistrationAuthReq message to SUBSCRIBER MANAGER, with a *doAuthenticate* flag set to false. This way, SUBSCRIBER MANAGER realizes that it will not perform any authentication for this user, and immediately sends a RegistrationAuthConf message with result true. On the other hand, in the original SIP-to-Mobile Gateway, a Location Update in the SS7 network is performed right after this step, which equips the SIP-to-Mobile Gateway with VLR functionality. However, in the SCN, no location update in the SS7 network is performed, since the actual residence of the SCN-enabled user is its home network domain, which is domain-1 in this case, rather than the SCN domain-0.

After receiving the RegistrationAuthConf message, SIP REGISTRAR sends UpdateLocationReqSMGR message to the Subscriber Manager, which includes the Contact URI's of this user in its REGISTER message. Subscriber Manager saves the location information; i.e., uri-IP address mapping, in the database and returns back an UpdateLocationConfSMGR message to the SIP REGISTRAR. Note that this location update corresponds to the location of the user in the subscriber database of SCN, rather than the location in the SS7 network. Afterwards, SIP REGISTRAR retrieves the saved location information via GetSubscriberLocationListReq message. Upon successful reception of the GetSubscriberLocationListConf message, SIP REGISTRAR sends RegistrationConfRegistrar message to SIP PROXY, which in turn sends RegistrationConfRegistrar message to SIP PROXY. Finally, SIP PROXY sends RegistrationConf

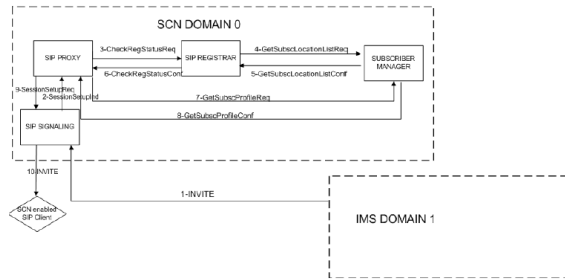


Fig. 7. Detailed call flow to an SCN-enabled client

message to SIP SIGNALING, which then sends an 200 OK message corresponding to the initially received REGISTER message.

Figure 7 depicts the detailed call flow from an IMS domain- 1 to an SCN capable client, whose home domain is also domain-1 but is an SCN user. Firstly, SIP SIGNALING software entity sends a SessionSetupInd message to SIP PROXY in response to receiving the INVITE message. SIP PROXY then checks whether the called address is registered by sending a CheckRegStatusReq message to SIP REGISTRAR, which then finds out that it is indeed registered, since the location of it was saved during registration. SIP REGISTRAR retrieves the registration status of the called address by sending a GetSubscLocationListReq message to SUBSCRIBER MANAGER. Finally, SIP PROXY forwards this message by sending SessionSetupReq message to SIP SIGNALING, which then sends the previously received INVITE message to its destination.

6 Conclusion

In this paper, we proposed a novel IMS concept, referred to as Service Concentration Node (SCN). Contrary to the existing IMS architecture, SCN concept enables the users to utilize IMS services offered in domains different than their home domain. This way, operators that currently lack the infrastructure to offer rich IMS services to their subscriber base are able to do so by signing an agreement with another operator that can offer these services. Note that SCN is also able to communicate with other IMS nodes such as Service Capability Interaction Management (SCIM) module. We have also outlined the overall as well as the detailed design of our proposed SCN scheme for both registration and call flow processes.

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