# Service Invocation Issues within the IP Multimedia Subsystem

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***Abstract***
IP Multimedia Subsystem (IMS) is a standardized service control overlay meant to offer rich IP multimedia services to the users in different networks. However, IMS service invocation as specified by 3GPP encounters multiple issues and ambiguities including "*service conflict*" and "*service composition*" management. In this paper, we highlight these issues by focusing on the following question: *How should IMS interact with multiple services during a single IP multimedia session while 1) detecting and resolving potential conflicts between these services and 2) ensuring the interoperability and cooperation between these services?* Based on the requirements and characteristics of Next Generation Network (NGN) service architecture, we propose architectural and functional improvements to the service invocation mechanism of IMS in order to answer to this question.
***Key words:*** IMS, SIP, NGN, Service Invocation, Service Interaction Management.

## 1 Introduction

Today, different networks (e.g. PSTN, GSM/UMTS) offer services through network-specific service platforms. The "*convergence*" of these networks and service platforms will lead to a single enhanced service architecture that offers to users a vast range of rich services including: audio/video over IP, conferencing, messaging, presence and location based services, multimedia streaming and push services. Moreover, this converged service architecture should enable different application servers to share common service building blocks in order to, on the one hand, reduce the time to market and to be business efficient, and on the other hand, satisfy their subscribers by providing personalized services.

The evolutions of UMTS, particularly by the introduction of IMS [1] (setting up in Release 5 of 3GPP (3rd Generation Partnership Project) and improved in Releases 6 and 7) realize this service convergence paradigm for 3G networks. IMS provides this service convergence by allowing the interworking with existing fixed and mobile networks and by enabling the establishment of all-IP communications between all types of users.

IMS will also enable the use of new types of service platforms over mobile networks: typical IT services platforms (IBM or BEA application servers) could indeed be used over IMS. This will achieve the IT and telecom convergence for mobile networks.

However, offering various services through the converged service architecture in IMS must deal with various service offering challenges, specially the "service interaction management" issue: How should services interact in order not only to manage the composition between services but also to detect and resolve the conflicts occurred between services invoked during an IP multimedia session? Overcoming these challenges must remain transparent to the users and should not force service providers and network operators to carry out deep changes. Conversely, it must provide means of flexible access to various NGN services. We should recall that NGN services are not necessarily the innovative multimedia services. They also include a wide range of legacy services already provided in isolated service platforms such as CAMEL (Customized Applications for Mobile Network Enhanced Logic [2]) services that will be merged into a common integrated, converged and coherent service environment to be offered to various users.

In the last few years, NGN concept, as a path toward a new integrated broadband network has been widely studied: [5] contains an inclusive overview of the history, definition, requirements and future trends of NGN standards. [6] presents the use cases of services and capabilities to be supported in NGN. [7] discusses the general principles, functional representation and typical implementation issues of NGN. According to these studies, we observe that the service architecture of NGN, as an enhanced IP-based network to manage rapid evolutions in the multimedia service domain, must provide the following features: 1) Open Network Architecture for enabling a layered architecture in which "Session Control Layer" and "Service Layer" functions are separated and the independent improvement and extension of each layer is ensured. 2) Open Service Architecture for providing a common and flexible service creation, control and execution framework that supports different multimedia services in different networks and enables both service providers and users to simply introduce innovative and personalized services. Hence, IMS, developing its service architecture in favor of NGN must be provided with additional mechanisms to orchestrate the invocation of various NGN services. The overall research approach of this paper consists of an overview of the current service invocation issues within IMS, followed by outlining significant propositions to overcome these issues and shortcomings.

The reminder of the paper is organized as follows: Section 2 outlines backgrounds on the functional architecture of IMS and describes the heterogeneous service platforms integrated in IMS. In section 3, we discuss about service conflict and service composition management as two defined service invocation issues within IMS. Our proposed solutions for dealing with these issues are presented in section 4. Finally, we conclude this paper with a discussion assessing the identified issues and propositions.

## 2 IP Multimedia Subsystem of UMTS

In the functional architecture of IMS [1], illustrated in figure 1, functions of session control layer and service layer are separated and hence the autonomy and independence of each layer are ensured.

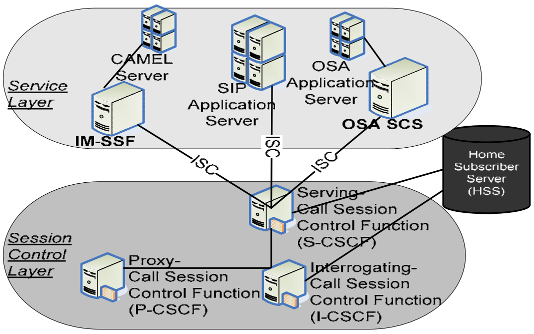


Figure 1: Functional Architecture of IMS

### 2.1 Session Control Layer

Session control layer of IMS performs multimedia session establishment, modification, control and termination by using SIP (Session Initiation Protocol) [4]. The following SIP proxies called Call Session Control Function (CSCF) are included in the session control layer of IMS:

- *P-CSCF* (Proxy-CSCF), which is the first contact point of IMS for user.
- *I-CSCF* (Interrogating-CSCF), which is the entry point within the IMS operator's network for other operators.
- *S-CSCF* (Serving-CSCF), which is the brain of IMS for session controlling and service invocation.

The IMS subscriber's profile is stored in a central database called Home Subscriber Server (HSS). During service registration and session establishment procedures, S-CSCF retrieves the user profile from HSS and stores it for further session establishment procedures.

### 2.2 Service Layer

Functional architecture of IMS is available for various services (SIP-based or non-SIP-based), and even if the protocol used by services is not always SIP, IMS supports access to these non-SIP-based services. Application Servers hosted in service layer of IMS are:

- SIP Application Server that hosts and executes SIP-based services. Presence, Multimedia Messaging and Conferencing are the examples of SIP-based services that may be used in IMS independently or may be applied in the creation of various integrated services like Multimedia Gaming, Chat rooms and e-learning.
- Open Service Access (OSA)-Application Server that allows third-party service providers to use UMTS network's capabilities through the OSA Application Programming Interface (API). This interface interacts with the SIP-based entities (S-CSCF or SIP Application Server) through a Parlay/OSA gateway called OSA Service Capability Server (OSA SCS).
- Customized Applications for Mobile Network Enhanced Logic (CAMEL) Server that, based on IN (Intelligent Network) concepts, allows reusing of existing GSM/UMTS IN services such as prepaid services. In the functional architecture of IMS, IM-SSF (IP Multimedia Service Switching Function) is an interworking functional entity which provides access to CAMEL Server.

### 2.3 The interface between Session Control Layer and Service Layer

In functional architecture of IMS, the interface between S-CSCF in session control layer and the service entities in service layer is defined as SIP-based IP Multimedia Service Control (ISC) interface. In fact, for S-CSCF, the entire SIP-based and non-SIP-based services act as SIP Application Server and S-CSCF interacts with them through ISC interface. The current service invocation mechanism of IMS is based on the IMS user's service profile evaluation performed by S-CSCF. A subset of IMS user's service profile is illustrated in figure 2.

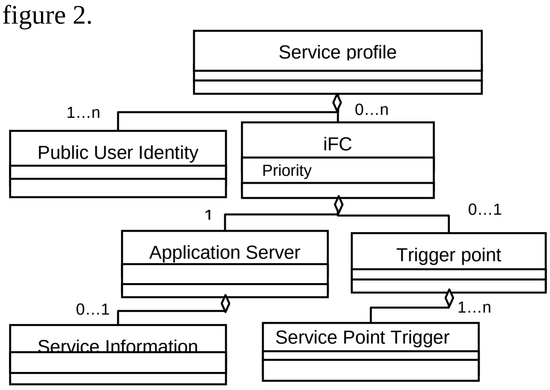


Figure 2: A Subset of IMS user Service Profile

This service profile contains an ordered list of initial Filter Criteria (iFC) that is a couple of a Boolean expression (Trigger Point) and an Application Server address associated to this Trigger Point. The conditions in Trigger Point may be made on SIP method, SIP headers and their content, originating or terminating session cases and on the session description in the body of SIP message. If a Trigger Point is met, S-CSCF sends the request to the Application Server associated with the Trigger Point.

Once an IMS subscriber registers to IMS, S-CSCF retrieves the service profile of the IMS subscriber from HSS and starts to evaluate this profile in order to find out which Application Servers must be invoked. This service invocation mechanism, which is based on static service invocation rules defined by initial Filter Criteria; ignores the following challenges: *1) How Application servers can reuse and share different service building blocks? 2) How two or more services are invoked during one IP multimedia session, without the occurrence of any conflict between them?* These two challenges raise respectively two separated problems during the service invocation: “Service Composition management” and “Service Conflict management”. In the next section, we discuss about these problems in more detail.

## 3 Service Invocation Challenges in IMS

IMS needs to be provided with an intelligent service invocation mechanism that 1) enables to manage the composition of different service building blocks by different services and 2) prevents or detects and resolves the eventual conflicts that occur between Application Servers that are invoked during an IP multimedia session.

### 3.1 Service Composition

Enabling the interoperability and cooperation between different modular and self-contained service building blocks (called Service Capabilities) in the service layer of IMS brings the following advantages to the service layer: 1) *Enriching the services by enabling and managing the integration of standardized Service Capabilities in these services*, 2) *Preventing the redundancy of the same functionalities offered by the Service Capabilities and implemented by different Application Servers.*

However, providing such service architecture requires introducing an additional functionality for managing the composition of services. Managing the composition of a service consists principally of making available the Service Capabilities for services, controlling the access of different services to Service Capabilities and managing the interactions between services and Service Capabilities on respecting the confidentiality of the user context.

In related research works, managing the composition of services built on Application Servers had been studied in a vast scope. [8] presents a semantics-based service composition architecture. This architecture supports semantic representation of components, discovers components required to compose a service and builds the requested service based on its semantics and the semantics of the discovered components. [9] describes a CORBA-based service development environment over which an OSA/Parlay gateway with a Parlay call control interface is implemented. This later performs registration, trust and security, discovery, service agreement management, service profile using and subscription tasks. [10] presents a fully decentralized service composition framework that provides statistical QoS assurances and load balancing for service composition.

However, implementing these propositions in IMS would require the coherency of these non SIP-based service composition management propositions with the SIP-based service invocation mechanism of IMS. In fact, adapting these propositions to IMS will lead to complex and costly solutions that can be prevented by applying a SIP-based service composition management mechanism. Hence, as an alternative to the already existing solutions, we will propose in section 4.1 a SIP-based service composition management mechanism that is entirely compliant with IMS. We propose to include this proposition in the service invocation mechanism of IMS in order to enable it to manage the interoperability and cooperation between different Service Capabilities shared and reused by various integrated services.

### 3.2 Service Conflict

Different Application Servers invoked during one session may behave correctly separately i.e. independent of each other, but not when running together. In other words, simultaneous invocation of different Application Servers during a session may result in incorrect or unexpected behaviors. Therefore, the service architecture must be supplied with a mechanism that whether prevents these service conflicts, or detects and resolves them. This service conflict issue has been widely studied for IN (Intelligent Network) services but has to be studied further for IMS. For example, [11] and [12] propose Offline service conflict detection and resolution mechanisms. These mechanisms are called Offline since they manage the service conflicts before that the services are invoked. The first proposition is based on a formal service specification method that is extensible by integrating any new kinds of undesirable service conflicts to the formal service specification method. The second proposition uses an event driven transition system that contains the service properties (applied for detecting the conflicts) as well as the service conflict resolution rules. Nevertheless, due to the unpredictable behavior of services as well as the vast introduction of new services, Offline service conflict management mechanisms can not resolve all of the service conflicts and Online mechanisms are needed to resolve the conflicts during the service run-time.

[13] and [14] propose an Online service conflict detection mechanism by integrating a central Service Interaction Manager Agent between the end user and SIP proxies. This agent traces the current session processing context and detects the

occurrence of incompatibilities between the already running and newly loaded services. But this research work lacks a suggestion for dealing with the service conflict resolution mechanisms.
In section 4.2, we propose a SIP-based service conflict detection and resolution solution to be integrated in the service invocation mechanism of IMS in order to provide IMS with both Offline and Online service conflict detection and resolution mechanisms.

## 4 Proposed Modifications to the Service Invocation Mechanism of IMS

In this section, we present our propositions to modify the service invocation mechanism of IMS in order to provide IMS with SIP-based service composition and service conflict management mechanisms.

### 4.1 Service Composition Management

To provide IMS with a SIP-based service composition management mechanism we need:

1) To introduce a functional entity that manages the interoperability and cooperation between different Application Servers and controls the way different Service Capabilities are shared and reused by various integrated services,
2) To define the required mechanisms for this functional entity in order to control the access of integrated services to the Service Capabilities and to manage service integration.

#### 4.1.1 Service Capability Interaction Manager (SCIM)

Service Capability Interaction Manager (SCIM) is a SIP Application Server initially introduced by 3GPP for managing the interactions between application servers. However, the service interaction management functionalities of SCIM are not yet specified by 3GPP. Following our proposition in [15] and as illustrated in figure 3, we propose to introduce Service Capability Interaction Manager between S-CSCF (in session control layer) and Application Servers (in service layer) for providing IMS with a mechanism for supporting cooperation and interoperability between services.

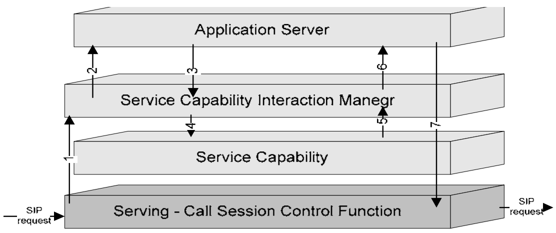

Figure 3: Proposed Service Composition Management Mechanism

In this proposition, the composition of each Application Server is managed by one SCIM and each SCIM can manage the composition of multiple Application Servers.

In fact, SCIM represents a boundary between network operator domain and third-party service provider's domain. Thus by including service composition management mechanisms over SCIM different service providers will be provided with the possibility of introducing value-added and integrated Application Servers while sharing a limited set of standardized Service Capabilities provided by IMS network operator. SCIM enables IMS network operator to control this cooperation and interoperability between services based on the constraints and agreements specified between network operator and service provider.
For instance, a Presence based calling Application Server (that enables the calls only if the callee is available) uses a Presence Service Capability to recognize the availability of the callee. Another example would be a Voicemail Application Server (that forwards the incoming calls to voice messaging server if the callee is not available) can reuse the same Presence Service Capability to send the incoming calls to a messaging server if the callee is not available. This example is presented in figure 4.

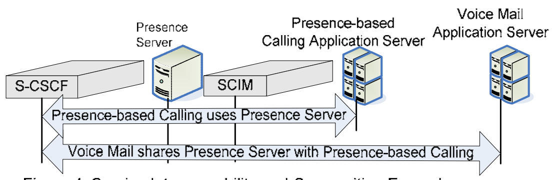

Figure 4: Service Interoperability and Composition Example

#### 4.1.2 Defined Service Composition Management Mechanism over SCIM

In our proposition, we provide SCIM with a *Service Profile-like* service composition information called Service Capability Profile (illustrated in figure 5).

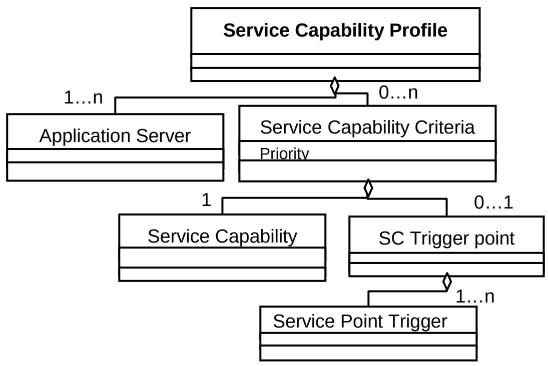

Figure 5: Proposed Service Capability Profile of Application Server

This Service Capability Profile indicates for each Application Server, in what condition (Service Capability Trigger Point in Service Capability Criteria class) which Service Capability is allowed to be used. This condition is verified on the SIP messages received from Application Server. If the condition is met, the related Service Capability will be available for the Application Server.

In table 1 we compare our SCIM based proposition with the alternative OSA-based service composition management mechanisms:

| | OSA-based Solution | SCIM-based Solution |
|---|---|---|
| SIP-based | - | ++ |
| Modular Service Definition | + | + |
| Adaptable for IMS | + | ++ |
| Security | + | + |
| Dynamic Service Binding | ++ | Considered as perspective to our work |
| Network Independency | ++ | - (IMS specific) |
| Developer Community | IT | SIP & Telecom |
| Service Invocation Condition | - | ++ |

Table 1: OSA-based vs. Our SCIM-based Service Composition Management Propositions

As presented in table 1, the significant advantage brought by our proposition is to provide IMS with a SIP-based service composition management mechanism. Contrary to the alternative solution, it is flexibly IMS-adaptable and improves current IMS service invocation mechanism.

### 4.2 Service Conflict Management

To provide IMS with a SIP-based service conflict management mechanism we need:

1) To introduce a functional entity that manages the conflicts that may occur between different services invoked during an IP multimedia session,

2) To define the required mechanisms for this functional entity in order to prevent or detect and resolve the eventual conflicts.

#### 4.2.1 Service Broker

In [17], we propose a distributed architecture in which the required functionalities for managing the conflicts between services are dispatched over S-CSCFs. This distributed architecture prevents the bottleneck problems of a centralized service conflict manager and offers a scalable service platform.

Adding service conflict management functionalities to S-CSCF improves the current service invocation mechanism of IMS in which detecting and resolving the potential conflicts that may occur between invoked services during an IP multimedia session is neglected. Hence, as illustrated in figure 6, we associate to each S-CSCF a Service Broker over which we introduce service conflict management functionalities.

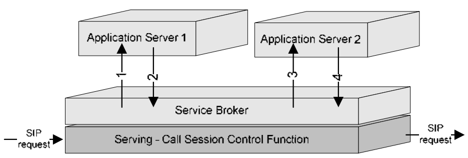


Figure 6: Proposed Service Conflict Management Mechanism

#### 4.2.2 Defined Service Conflict Management Mechanism over Service Broker

Service Broker should be provided with service information that indicates if the already invoked Application Servers are compatible with the Application Servers to be invoked or not. In other words, a Service Broker needs following parameters: “Service Description” and “Record of the Invoked Services”.

- <u>Service Description (Online Solution)</u>:

While describing precisely the behavior of Application Server is very complex and violates the confidential aspects of Application Servers, we focus on an extended SIP header that simply and concretely describes the services. “Service-Rule” header [16], added by invoked Application Server to the outgoing SIP message, with following syntax: *“Service-Rule: [Applicability]; [messagePart]; [forbiddenValues]”*, indicates which values (forbiddenValues) are not accepted over which elements (messagePart) of which SIP message (Applicability). For example, the following service-rule: *“Service-Rule: Applicability=480;messagePart=requestURI,To; forbiddenValue s=all”* integrated by an Application Server to an Invite request, indicates that if the destination is busy (480 SIP response), the session should not be forwarded to another destination (the TO header and the request URI must not be changed).

In order to prevent Application Server to define abusive rules, Service Broker verifies if the defined rule is acceptable or not. This verification is performed by comparing the rule with a list of “*unauthorized rules*” initially defined by network over Service Broker. If Application Server defines a rule that is not accepted by Service Broker, this later drops the message received from Application Server, i.e. Service Broker continues the session establishment procedure by neglecting the SIP message received from Application Server and by considering the SIP message that has been sent to Application Server (before service invocation).

Moreover, Service Broker verifies if the SIP message received from Application Server respects the already included rules by the previously invoked Application Servers. If the lastly invoked Application Server does not respect the previously defined rules, then the Service Broker drops the message received by Application Server and continues the session establishment procedure by neglecting this SIP message.

- <u>Record of Invoked Services (Offline Solution)</u>:

“Service-ID” is another extended SIP header that we propose to be included by the invoked Application Servers to the SIP message that they send back to the Service Broker. The content of this header will be a unique identifier associated to each widely deployed service. This proposition is alongside with the 3GPP proposition [3] for defining and associating a globally unique identifier to each IMS communication service. Based on this proposition, before each service invocation, Service Broker verifies if the Application Server to be invoked is not in conflict with the already invoked Application Servers. This verification is performed by: 1) controlling the content of “Service-ID” header(s) added by the previously invoked Application Server(s) to SIP message and 2) providing Service Broker with a service conflict detection and resolution database that lists a limited set of conflicts to be detected and resolved Offline, i.e. before that service is invoked.

Hence, Service Broker compares the content of “Service-ID” header(s) added to the message by previously invoked Application Servers, with the identity of Application Server that must be invoked (based on iFC evaluation). In case of conflict, Service Broker acts as defined in the service conflict detection and resolution database. Table 2 presents the advantages brought by this proposition to the IMS service invocation mechanism.

| Characteristic | Details |
|---|---|
| Dynamic Contribution of Application Server | Including the service information parameters “Service-Rule” and “Service-ID” headers to the SIP message, by Application Server, during the session establishment time |
| Intelligent Session Establishment Control | • Comparing the rules defined by an Application Server with: • Network defined unauthorized rules • Previously defined service rules during the session • Detecting and resolving the eventual conflict between the Application Server to be invoked and the already invoked Application Servers according to the “Service Conflict Detection and Resolution Database” defined over Service Broker |

Table 2: Advantages of the Proposed Service Conflict Management Mechanism

## 5 Conclusions, Discussion and Perspectives

In this paper, after reviewing the current service invocation issues in IMS, we proposed the architectural and functional improvements in order to deal with them. These propositions focus on SIP-based “service composition” and “service conflict” management mechanisms that are compatible and easily adaptable to the SIP-based service invocation mechanism of IMS. Moreover, they provide IMS with a flexible service control framework supporting different services in different networks. In addition, they enable the introduction, deployment and execution of personalized and adaptive services by service providers. However, realizing these propositions requires that different network operators agree on common user and service profile templates in order to enable straightforward service information exchange between their network entities. Besides, the service providers should dispose of modular representation of their services to ease dynamic composition and decomposition of Service Capabilities in order to create innovative integrated services. We consider this need as a perspective of works towards IMS service modelling efforts.

In the next step of our research work, we will extend the proposed service composition management mechanism by including dynamic service binding possibility through service discovery mechanisms in order to enable services to involve dynamically a greater range of Service Capabilities (based on their requirements). In addition, we will include inter-operator agreement considerations in the service conflict management mechanism in order to enable privacy control during exchange of service information (Service-Rule, Service-ID) between different end parties. Finally, we will focus on the development and implementation of the proposed service composition and service conflict management mechanisms over IMS and evaluate the session establishment delay consequences due to the introduction of these mechanisms into the service invocation mechanism of IMS.

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