Online Charging for IMS-Based Inter-domain Composite Services

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Abstract. In order to manage financial risks online charging of composite services is becoming increasingly important for service providers to support service delivery in inter-domain environments. The 3rd Generation Partnership Project (3GPP) has developed a framework for off-line and online charging of IMS-based services. At service level, delivery of composite services often involves many service providers, where each service provider is responsible for the delivery of one or more service components (e.g. access service, IMS communication service, content service, etc.). Current Online Charging System (OCS) specified by 3GPPP does not support an online charging function for composite services. This paper discusses a number of implications of online charging of composite services, in particular inter-domain composite services. It addresses important shortcomings of the current 3GPP online charging architecture and suggests a way to overcome these shortcomings. The contribution of this paper is twofold. Firstly, it proposes an information model to support charging of inter-domain composite services. The proposed information model is based on the NGOSS and SID concepts of the TeleManagement Forum. Secondly, it proposes additional functionalities required for existing OCS in IMS to handle online charging of inter-domain composite services.

Keywords: Online charging, composite services, IP Multimedia Subsystem (IMS), inter-domain.

1 Introduction

Most telecom service providers are currently implementing multi-service IP infrastructures to cope with huge customer demand for advanced multimedia services over fixed and wireless broadband networks. Rapid penetration of smart phones with comfortable large screen sizes also contributes to a positive customer experience. The combination of these two trends results in a significant growth of usage of mobile

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services such as Voice, SMS, MMS, email, location-based services, instant messaging, community gaming, IPTV, etc. In particular, these multimedia services are composed of services that are delivered by *different* providers in different administrative domains. At service level, delivery of composite multimedia services may involve different service providers such as e.g. telecom service providers, content providers or game providers. We therefore speak of *inter-domain composite* services.

The 3rd Generation Partnership Project (3GPP) has developed the IP Multimedia Sub-system (IMS) [1] to support multimedia services. Besides the IMS architecture, the 3GPP also provides a framework for off-line and online charging. Off-line charging implies that charging for service usage occurs after a service event or service session has occurred. Online charging implies that charging occurs right after a service event has occurred or during a service session usage.

Now, customers of composite services want (near) real-time charging and billing information to manage their expenses while using these services. Service providers also have the same needs in order to manage their financial risks. However, today's charging systems are not capable of dealing with requirements related to composite services. In particular, current online charging systems specified by 3GPPP [2] do not support online charging functions for inter-domain composite services.

In this paper a number of implications are discussed of online charging of inter-domain composite services. Note that here inter-domain is the generic case. The case where one deals with composite services in the same administrative domain can be derived from it. Hence, in this paper significant shortcomings of the current 3GPP online charging architecture are described while also a way to overcome these shortcomings is given. The major contribution of this paper is twofold. *Firstly*, an information model is proposed to support charging of inter-domain composite services. The proposed information model is based on the TeleManagement Forum's (TMF) programme of New Generation Operations Systems and Software (NGOSS) [3, 4]. S*econdly*, in this paper additional functionalities are suggested for the current Online Charging System (OCS) of IMS in order to handle online charging of composite services.

The remainder of this paper is organized as follow: Section 2 provides a brief overview of related work. Section 3 discusses a motivating example in which composite services are delivered across different domains. Section 4 presents the problem domain of online charging of composite services. Section 5 proposes a service composition information model. Section 6 discusses important functionalities for coping with the charging of composite services. Finally, Section 7 presents the conclusions and contribution of this paper together with some future directions.

2 Related Work

In this section related work with respect to the service composition of inter-domain services and its charging is described.

The TMF launched an initiative on their Service Delivery Framework (SDF) in 2007, which aims at specifying standards for managing service delivery across multiple administrative domains. The ultimate objective of these future standards is to enhance partnerships among many kinds of service providers and to achieve efficient interoperation between different domains. In such an environment the service management processes of all service providers involved need to be orchestrated to ensure smooth and consistent service delivery to end-users. The work in progress of TMF [5] shows clear direction of the SDF to standardize “overlay” service delivery platforms that will rely on existing and future networks such as the IMS core infrastructure.

The 3GPP has proposed the concept of a *Service Broker* to enable service composition and orchestration [6, 7]. In the context of IMS a service broker has two fundamental tasks: 1. service execution and orchestration, which ensures that sub-services (being part of a composite service) are deployed and co-exist in harmony; and 2. service offering coordination, which ensures that service composition is conducted in real-time in order to fulfill requests of customers. One can think of three alternative service broker models, i.e. a centralized, distributed or hybrid model. A centralized service broker model implies that different application servers interact with a single S-CSCF (Serving-Call Session Control Function) via a single service broker. A distributed service broker model implies only a one-to-one relationship between an application server and a service broker. In turn, service brokers communicate with a single S-CSCF. Finally, a hybrid service broker model allows one-to-one as well as many-to-one relationships between application servers and service brokers. In turn, service brokers communicate with a single S-CSCF.

With respect to charging, the 3GPP has proposed two reference charging models for different service scenarios [2], namely: an off-line and an online charging model. The latter charging model covers near real-time charging issues such as charging authorization, credit control during service sessions. However, it lacks a service composition model to deal with charging of composite services. For instance, a video conference can fall back from video plus voice to only voice due to some network problem. This introduces a change in charging of the voice component for the rest of the conversation. In this kind of situation, it is necessary for a charging system to keep track of the service composition information to adapt charging accordingly.

In [12], the authors introduced a concept called Time Interval Calculation Algorithm (TICA) for online charging to deal with performance issues. That is, to avoid large overhead caused by credit checks. TICA supports flexible tariff functions to cope with sophisticated business relationships between the involved business partners. TICA and the proposed solution in this paper are complementary. Hence, a combination of TICA and our proposed solution helps to tackle performance issues of online charging of inter-domain composite services.

3 An Inter-domain Service Scenario

Below we will describe a motivating example of a service scenario with inter-domain service composition and related charging. In our scenario a young business professional Jane leaves her office after a working day and takes the train back home. During the journey she wants to catch the evening news from a national television channel. Jane uses her smart phone to connect to the 4G mobile network of her service provider and requests on-demand TV service. The service provider responds by offering her two options: 1. premium TV-on-demand (TVoD) service without mobile advertising for a premium price and 2. TVoD service with mobile advertising for a sponsored price. As she likes discounts Jane first chooses mobile advertising integrated in the TVoD service. At some point in time she is bored with this service and switches the advertising banner off.

In our example scenario the Service Provider is assumed to be capable of providing core IMS services (e.g. access, mobile internet, VoIP, Push-to-talk, Messaging, etc.) using an IMS-based infrastructure. Here the TVoD services and the mobile advertising service are provided by third parties in other administrative domains. The business rationale behind this scenario is as follows. On the service delivery side: the Service Provider combines the TVoD services and mobile advertising to create attractive service offerings to customers. The Service Provider purchases the TVoD services from the TV-on-demand Provider. On the paying side: the Mobile Advertising Provider pays the Service Provider for inserting mobile advertising into each TVoD service session. Furthermore, Jane pays for the composite service to the Service Provider (all-in). However, Jane receives discounts for the TVoD services from the Service Provider by accepting mobile advertising. If Jane switches off the mobile advertising during the TVoD service session, the premium price is applied from that point forwards.

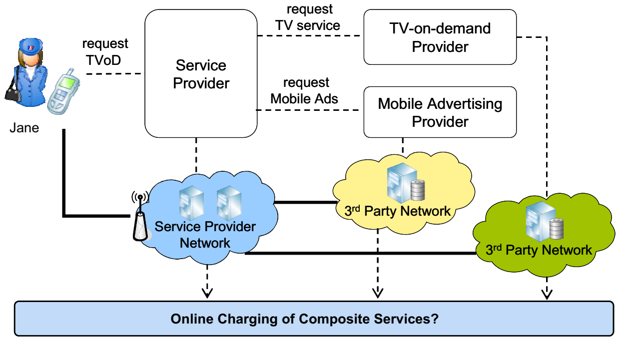

Fig. 1. Inter-domain service scenario depicting functional relationships (dash lines) and the physical paths of the delivered data (solid lines). The arrows and the blue box denote the problem domain of online charging over multiple administrative domains.

Figure 1. depicts the above described inter-domain service scenario. In this service scenario the Service Provider is responsible for the *user-facing* charging and billing of Jane, as well as the *3rd party-facing* charging and billing of the TVoD Provider and the Mobile Advertising Provider. Here, charging is expected to be online (near-real-time) in order to manage the financial risks for both the user Jane and the Service Provider.

4 Problem Domain of Online Charging of Composite Services

This section deals with the scope of our research into the problem domain of online charging of composite services. Moreover a summary of the research questions we deal with is given.

4.1 Research Scope

This paper focuses on online charging of composite services. Depending on the implementation strategy online charging may involve different distributed Online Charging Systems (OCS). However, we abstract from a concrete distribution and focus on one single OCS. We assume that composite services will be delivered across several administrative domains and across several delivery platforms. Hence, a combination of web services and IMS services based on SOA (Service Oriented Architecture) [7] is considered.

In order to master the complexity of such a service delivery, the concept of service broker as advocated in [6, 7] is used. There are different possible configurations of service brokers in an actual deployment. In this paper, two types of service broker are considered: 1. An IMS Service Broker within the IMS domain and 2. An Inter-domain Service Broker within the Web-Services domain. Here, the Inter-domain Service Broker is leading and is responsible for the end-to-end service composition for the user.

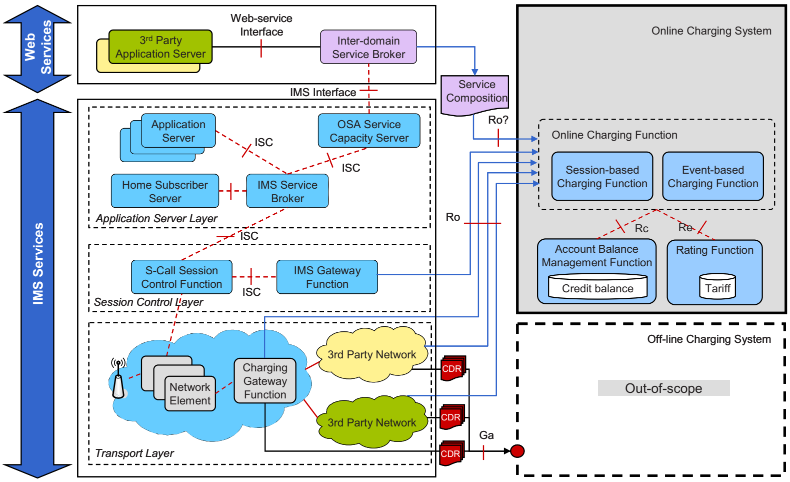

Fig. 2. Provisioning and Charging of Composite Services in an Inter-domain Environment

Figure 2 above illustrates a possible model for provisioning and charging of composite services in a multi-domain environment. A composite service is delivered across different administrative domains: the service provider domain, which is supported by IMS core infrastructure, and the third party domains, which are not necessarily supported by an IMS but some different network infrastructures. The service composition and orchestration occurs at the web-service level through the Inter-domain Service Broker. This implies that the Inter-domain Service Broker has the knowledge of the service composition and needs to communicate this information with the OSC for online charging purposes. Note that here off-line charging is out-of-scope.

4.2 Research Questions

The 3GPP framework describes online charging for both events and sessions. However, there exists no standard model yet for service composition within 3GPP specifications. Although an IMS service may consist of different service components (e.g. VoIP over IP-access), current online charging systems do not correlate charges between these service components. As a result, when a service component is added or removed from an incurred composite service session, adjustment of online charging due to possible tariff changes (e.g. zero rate bearer usage when a VoIP session is active) cannot be handled. Since the composition of a composite service may change at run time, online charging needs to adapt to this dynamic behavior as well. This implies that the OCS needs to have knowledge about how the ongoing service composition is built up and the corresponding tariff of an individual service component. Furthermore, charging policies need to be enforced appropriately according to some pre-defined service level agreement between the end-user and the service provider.

Hence we come up to the following research questions regarding online charging of composite services:

1. What is the service composition model used by the OCS? This involves information exchange between an inter-domain service broker function and the OCS.
2. Which technical details should be included in the service composition model? A charge request should contain enough details to enable the OCS to conduct credit reservations and correlate different charges.
3. How do the charging processes of individual service components influence each other during an ongoing service session? There must be a way to keep the state of service composition within the OCS. In addition, the cross dependency of tariff between different service components depends strongly on imposed charging policies. Hence, the OCS also needs to take charging policies in to account.

The above questions will be addressed in the sections 5 and 6 below where we propose solutions.

5 Service Composition Information

This section presents a service composition information model to deal with online charging of inter-domain composite services. An example is also given to concretize the proposed solution.

5.1 Service Composition in the Context of TMF's SDF

According to [5], there are three steps to arrive at the eventual service delivery, namely: product design, service creation and service execution. During the product design phase, a service designer from the service provider domain can look up available service components in a catalog and chooses the necessary service components to form a composite service. During the creation phase, the designed composite service is tested throughout. When a composite is accepted, a meta information model of the composite service is created and stored in a composite service catalog. In the last phase, whenever a user requests a composite service, an instance to the corresponding meta information model is generated. Figure 3 depicts when a meta service composition model comes into existence.

In order to compose a composite service, the service provider sometimes needs to acquire external services from third party providers. A service composition model therefore must express the relationship between the constituent service components. The TMF has been working on the Shared Information/Data (SID) model [4], which provides guidelines for the modeling of information/data for the purpose of product design, service construct and service provisioning. Currently, the SID model is widely accepted as standard in the industry. Among many aspects, the SID model addresses the basic entities: product, service, end-user-facing service and provider-facing service and their relationships. The next section will discuss a service composition information model based on SID, which can be used for online charging of composite services.

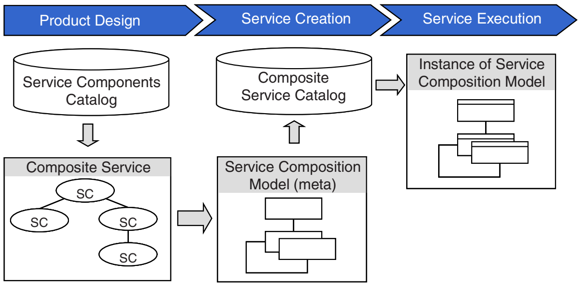

Fig. 3. Service Composition Information in the context of TMF's SDF

5.2 Service Composition Model

A `Product` is a particular "item" that an end-user can buy. For example, the end-user can browse through a list of products (e.g. video's) and pick out a preferred one. A `Service` is part of a `Product`. A `Service` cannot exist by itself, but is bound to a `Product`. An end-user can only buy a product, not a service. For example, the end-user buys 30 minute of ToVD of channel A (as a product) and experience high quality news (as a service). A `Service` represents the things, which are experienced by an end-user. A `Provider-facing Service` represents the resources which are needed to support the `End-user-facing Service`, which is to the `Service Provider` but invisible to an end-user.

The heart of the service composition is the `Service`, which is distinguished into an `End-user-facing Service` and a `Provider-facing Service`. The `End-user-facing Service` is linked to `Product`, which an end-user can choose. The `Provider-facing Service` consists of one or more `Atomic Services`, which can be `Provider Services` (i.e. internal resources), or `Partner-facing services` (i.e. external resources) or both. The relationship between the `Provider-facing Service` and the `Atomic Service` is a transformation duality relationship [8, 10]. Hence, in order to arrive at a `Provider-facing Service`, the `Service Provider` needs to compose a service session from different service components. Figure 4 below depicts the service composition model.

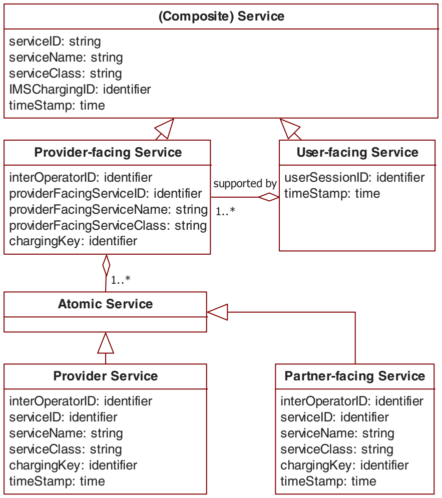

Fig. 4. Service Composition Model ChargingKey

The separation between the `End-user-facing Service` and `Provider-facing Service` makes it possible to construct service session compositions which contain detailed information about how a service session is built and what service components are used in a service session. The *how* and the *what* are expressed by `Provider-facing Service`. What an end-user "experiences" is the `End-user-facing Service`, which is transparent and abstracted from detailed business information intended only to the `Service Provider`.

The service composition information model contains necessary detail information to ensure the correlation of service components and their corresponding charge. The following pieces of information are crucial:

- `serviceID` - an unique identifier of a provided composite service or a service component.
- `interOperatorID` – a unique identifier of a service provider or a 3rd party provider.
- `chargingKey` - an identifier used by the OCS to determine the tariff of a composite service or a service component.

The combination of an `interOperatorID`, the corresponding `serviceID` and the `chargingKey` allows for an appropriate credit authorization request at the OCS.

Figure 5 below shows an example of an instance of a service composition information created for a TVoD request as described in the service scenario of Section 2.

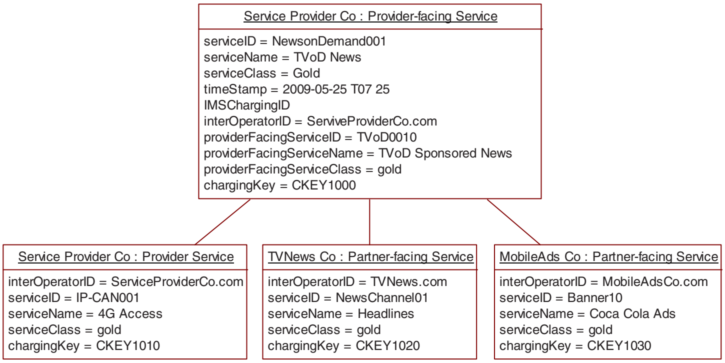

Fig. 5. Example of an instance of service composition sent to the OCS

6 Online Charging Functions for Supporting Composite Services

This section discusses the functionalities required for existing IMS's OCS to handle online charging of inter-domain composite services. In particular, it focuses on credit control mechanisms to deal with financial risks.

6.1 Credit Control for Composite Service Sessions

The main objective of online charging is to provide service providers with a mechanism to control user credit allowance. A credit allowance can be a pre-defined upper limit of a postpaid account (e.g. parents setting up spending limits for their children) or a current amount of money of a prepaid account. For this purpose, it is necessary to check the user credit balance prior to service provisioning. Moreover, if the user credit balance is sufficient, credit reservation must be made for the requested composite service session. In some cases, it will be necessary to create separate credit reservations for individual service components. To this extent, the Diameter Credit Control Application [13] is suitable to support the credit authorization requests for (inter-domain) composite service sessions. The charging of composite services can be divided into three phases:

1) *Charging request* – The Inter-domain Service Broker (ISB) sends a request to the OCS asking for charge authorization of a composite service session. The service composition information must be included in this request to enable the OCS determining the required credit reservation. At this point, the OCS creates a “parent claim” for the requested composite service. We note that the service session information sent from the ISB to the OCS must be combined with necessary information from the customer domain such as subscriber identifier and user identifier to enable the OSC to look up the appropriate account (not shown in this paper).
2) *Charging initiation* – If the user credit balance is sufficient, the ISB continues to initiate the required service components. For each service component a credit authorization request can be sent to the OCS, e.g by an individual

Application Server (AS). Each credit authorization request is followed by a corresponding credit authorization response which includes (among other things) an assigned usage quota (e.g. data or time unit).

3) *Service Charging* – During the service session usage, credit re-authorization might be necessary when the usage quota is approaching zero. An individual AS can undertake this action with the OCS independently. When the provisioning of a service component is terminated (this can be user-initiated, AS-initiated or OCS-initiated caused a credit constraint), the involved AS sends a final charge report to the OCS and a service termination message to the ISB.

Figure 6 shows the interaction between the ISB and OCS in the charging request phase. To avoid unnecessary load caused by credit requests for individual service components, we propose to conduct the "parent claim" for each request using a

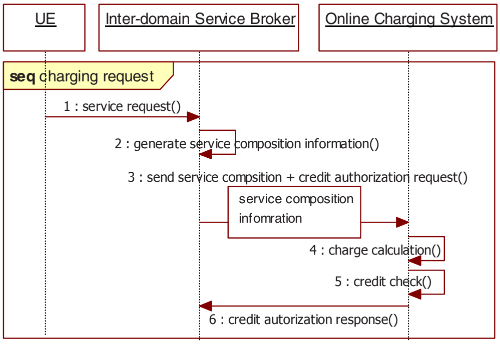

Fig. 6. Exchange of Service Communication Information

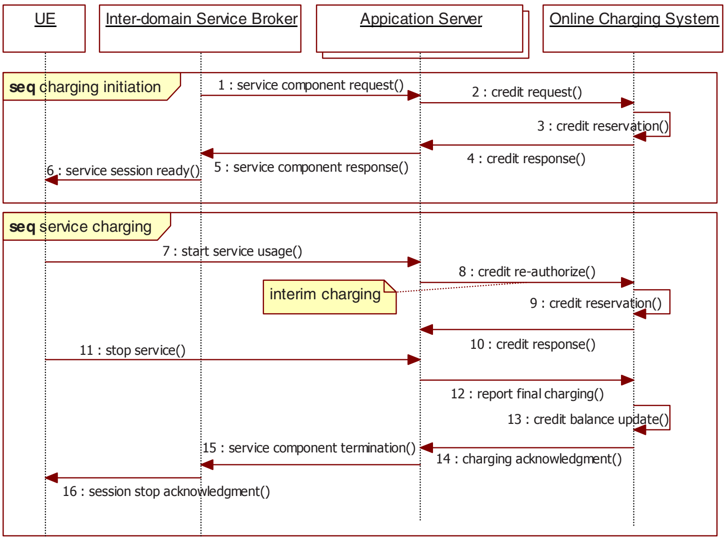

Fig. 7. Online Charging Initiation and Online Service Charging

limited data set of information contained in the service composition. Moreover, the combination of {`interOperatorID's + serviceID's + chargingKey's`} and their mutual relationships provide enough information for the OCS to determine the "parent claim". Hence, the ISB does not need to gather detailed technical information from the involved AS before being sure that the service provisioning is allowed.

Finally, Figure 7 below shows the interactions during the charging initiation and service charging phase between the User Equipment (UE), Inter-domain Service Broker (ISB), Application Server (AS) and Online Charging System (OCS). It is worthy to note that in case a service component is removed from a service session, the ISB needs to inform the UE about the new tariff of the remaining service session (not shown in Figure 7).

6.2 Dealing with Dynamic Change of Service Components

Online charging of composite services becomes complex when the composition of the ongoing composite service session changes (i.e. adding or removing service components) and when there is a tariff dependency between the involved service components. In such a situation, two major impacts on online charging are observed: 1. possible tariff changes of the remaining service components; 2. adjustment of user credit balance. To deal with these issues, we can think of three charging strategies.

The *first* strategy is to apply a tariff-dependent charging scheme. Here, the OCS must conduct credit reauthorization for the involved service components whenever the service composition changes. The advantage of this strategy is that it allows the OCS to adjust tariffs in near real-time, which can be desirable from a business viewpoint. The trade-off is that this strategy might induce extra load on the OCS. The *second* strategy is to use a tariff-independent charging scheme. Here, the OCS can apply a fixed tariff for each chargeable service component and a fixed tariff for each awardable service component (i.e. component from which an user receives compensation such as advertising). The advantage of this tariff-independent scheme is to avoid tariff recalculation, thus avoids extra load on the OCS. The *third* strategy is to apply a hybrid charging scheme where a combination of the two strategies is used. For instance, the tariff of a connectivity service component can be fixed, whereas the tariff of a TVoD service component depends on the rewarding of an advertising service component. In case the advertising component is removed from the service session, the OCS only needs to adjust one tariff for the TVoD component.

Moreover, in order to support the above charging strategies, existing functions within the OCS such as SBCF (Session-Based Charging Function), ABMF (Account Balance Management Function) and RF (Rating Function) need to take into account the dynamic character of the composite services and the tariff dependency amongst the service components. For instance, the ABMF needs to manage both "credit claims" of chargeable service component as well as the "rewarding prospect" of awardable service component.

6.3 Impact on Existing 3GPP Interfaces

Regarding the interfaces of the OCS, the main impact of our proposed solution in 6.1 and 6.2 is on the Ro reference point between the ISB and the OCS [11]. The current specification of the Ro reference is only capable of supporting "flat" structure of service components. Thus, no distinction can be made between a composite service as a whole and its (sub) service components. However, the hierarchical structure of service components and their corresponding charging keys are critical for the determination of the charging dependencies between service components. As a result, some adaptation should be made at the Ro reference point to enable the exchange of service composition information sent from the ISB to the OCS. Altogether, having a hierarchical structure of service components, their corresponding charging keys and an adapted Ro reference point will allow us to apply flexible charging policies. Hence, this extension of the capability of the OCS will support a broad variety of business models between service partners in different domains.

7 Conclusion and Future Work

This paper addresses the problems of online charging for composite services which are delivered across IMS-based and web-based infrastructures. One of the main challenges is the lack of a service composition information model that expresses the hierarchical structure of the service components and the relationships between their corresponding charging keys. To overcome this problem, a service composition model based on the SID framework is proposed. Furthermore, this paper discusses the implication of credit control when dealing with composite services and tariff dependency between the involved service components. To this extent, three charging strategies have been discussed in order to tackle the dynamic changes of service composition during run time. The impact of the proposed solution on the existing 3GPP charging reference architecture [2] is limited. Minor adaptation at the Ro reference point is required to include the proposed service composition information in the charging request phase.

Future work will study the correlation function that should be introduced to the OCS [11]. Further impact of online charging of composite services on existing functions such as OCF (Online Charging Function), ABMF (Account Balance Management Function) and RF (Rating Function) will be examined.

References

1. Cuevas, A., Moreno, J.I., Vidales, P., Einsiedler, H.: The IMS service platform: a solution for next-generation network operators to be more than bit pipes. IEEE Communication Magazine 44(8) (August 2006)
2. 3GPP, Charging Architecture and Principles, TS 32.240, version 8.4.0 (September 2008)
3. Strassner, J., Fleck, J., Huang, J., Faurer, C., Richardson, T.: TMF Whitepaper on NGOSS and MDA, version 1 (November 2003)
4. TMForum, Shared Information/Data (SID) Model – Business View Concepts, Principles and Domains, release 6 (November 2005)
5. TMForum, Service Delivery Framework Overview, release 2.0 (September 2008)
6. 3GPP, Study on Architecture Impacts of Service Brokering, TR 23.810, release 8.0 (September 2008)

7. Huslak, N.S., McQuaide, A.C.: Service Brokering: Opportunities and Challenges. In: International Conference on Intelligent Network (ICIN), Bordeaux, France, October 20-23 (2008)
8. Le, M.V., Beijnum, B.J.F., Niewenhuis, L.J.M., Huitema, G.B.: An Enterprise Model for Real-time Inter-domain Billing of Services. In: Workshop on ODP Enterprise Computing (WODPEC), Muchen (September 2008)
9. de Laat, C., Gross, G., Gommans, L., Vollbrecht, J., Spence, D.: Generic AAA Architecture, IETF RFC 2903 (August 2000)
10. Geerts, G.L., McCarthy, W.E.: An ontological analysis of the economic primitives of the extended-REA enterprise information architecture. International Journal of Accounting Information Systems 3, 1–16 (2002)
11. 3GPP, Online Charging System (OCS): Applications and interfaces, TS 32.296, version 8.2.0 (June 2008)
12. Kurtansky, P., Reichl, P., Stiller, B.: The Evaluation of the Efficient Prepaid Scheme TICA for All-IP Networks and Internet Services. In: 10th IEEE/IFIP Symposium on Integrated Network Management (IM 2007). IEEE, Munich (2007)
13. 3GPP, PS Domain Charging, TS 32.251 v8.3.0 (September 2008)
14. Hakala, H., Mattila, L., Koskinen, J.P., Stura, M., Loughney, J.: Credit Control Application, IETF RFC 4006 Diameter (August 2005)