Convergent Online Charging for Context-aware Mobile Services

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Abstract

Personalized and context-aware services are of high interest for Mobile Network Operators (MNOs) to keep existing and win new subscribers. Although such services are already available, they are frequently offered by third parties in a rather stand-alone manner. The challenge is to come up with appropriate interfaces that allow (a) third parties to offer their innovative services via an MNO's network infrastructure and (b) to charge corresponding service users through the MNO's existing Charging and Billing System in a robust and reliable way.

This article presents convergent online rating, charging and billing mechanisms for context-aware mobile services offered by third party service providers, e.g., local mobile services. The proposed mechanisms build upon international standards like IP Multimedia Subsystem (IMS) and Parlay X and are implemented as Web Services, such that they are fully applicable in SOA-based environments.

1. Introduction

To keep existing and to win new subscribers, Mobile Network Operators (MNOs) currently plan to offer an extensive bundle of new services, in particular rich real-time multimedia services. These services are built on emerging new standards like Next Generation Networks (NGN[1]) or the NGN architecture called IP Multimedia Subsystem (IMS) [1]. However, although MNOs have the networks and a large customer base, they do not have the intended new services yet. On the other side, there are many small service providers that want to offer their innovative services via widely accessible networks to potential customers. Unfortunately, although these potential customers exist, small service providers do not have the networks to reach them.

Opening their networks to third parties would allow network operators to offer a multitude of new services to existing and new customers as well as small service providers to offer their services as third party providers to many more customers. By offering standardized interfaces to their infrastructure, MNOs will considerably lower the entrance barrier for third party service providers.

In the area of mobile services, *context-aware services* are of special interest. For mobile users, the actual context is changing continuously, and services that are able to adapt to these context changes can be of great interest and benefit for users. Probably the most popular example for context information is the current geographic location, but other parameters, like the current temperature, can also enhance mobile services. As an example, consider a tourist guiding service that proposes the sites to visit depending on the weather conditions.

When an MNO allows third party providers to offer their services via the MNO's network, the MNO has to provide a secure, reliable solution for performing all the payment operations concerning the service usage. A promising solution that is able to satisfy all involved parties is *convergent charging and billing*. For end users, this basically means that all charges for the various services offered by different providers are presented in a *single bill*, while the expenses of the MNOs and third party providers are respected and settled in a fair and flexible manner.

This article proposes a *convergent online charging and billing system* built upon open international standards. Generally, *online charging* (or – in other words – real-time credit control, see Section 3.1) is a challenge w.r.t. performance and Quality-of-Service when serving thousands of potentially concurrently acting mobile users in a mobile telecom network. Note that although the proposed system is called "convergent online charging and billing system", it also supports *offline charging*, i.e., processing of post-event data records for charging and billing purposes.

[1] http://www.etsi.org/tispan/

2. Background

The work presented here is part of the ITEA[2] project *Local Mobile Services* (LOMS[3]). The LOMS project investigates methods and tools for development, deployment and use of context-aware mobile services. The main objective is to enable non-expert service providers to easily create and deploy smarter services.

LOMS has defined a corresponding role model [2] with LOMS Platform Operator, LOMS Service Operators, etc. (see Figure 1). In particular, it is distinguished between *LOMS Service Operators* (which are providing service templates) and non-expert *LOMS Service Providers* filling out these templates and deploying them on the LOMS Platform. Both the templates and the deployed services can make use of services provided by *External Providers* that offer contents, context information, or other basic services like news.

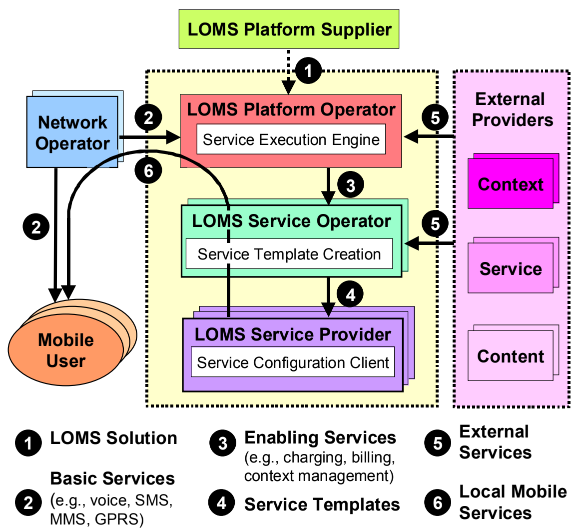

Figure 1: LOMS Role Model

In the LOMS role model, rating, charging and billing services are *enabling services* that are already deployed in the system and can therefore be referenced in the service templates. The aim of this paper is to provide an overview of the functionality of these enabling services and the conceptual considerations behind the interface definitions.

In the following sections, first the state-of-the-art of convergent online charging and billing is reviewed. Then the standards Parlay X and Diameter are described, upon which our proposed solution is built, before the solution itself is presented. The paper finishes with a conclusion and an outlook on future work.

[2] http://www.itea-office.org/
[3] http://www.loms-itea.org/

3. Charging and Billing

For mobile networks, the charging architecture and charging principles are specified by the 3rd Generation Partnership Project (3GPP) [3]. There, the so-called Charging and Billing System (CBS) is responsible for transaction handling, rating, online correlation and real-time management of subscriber accounts/balances.

3.1. Offline vs. Online Charging

There are two different charging principles: *offline* and *online charging*. For offline charging, the usage of network resources and services is reported to a CBS *after* the actual usage has been performed. Network nodes or application servers are collecting information about the usage of network resources and services. This usage information is stored and transferred to a billing system for post-event processing. The charges are then calculated after the service usage. Note that the charging information generated for offline charging does not affect the rendered service in real-time.

This is different for online charging: A subscriber account (managed by a corresponding online charging system, OCS) is checked *before* and *during* service usage whether access to the desired network resource(s) and services is granted or not. Here, charging information can affect the rendered service in real-time. Therefore a direct interaction between the OCS and the bearer/session/service control is required. Thus an OCS is able to perform real-time credit control of the involved parties. Its functionality includes transaction handling, rating, online correlation and real-time management of subscriber accounts and balances.

3.2. Convergent Charging and Billing

Convergence in future telecommunication networks has certainly more than one dimension and always impacts the charging and billing systems in place:

1. Online and offline charging mechanisms are both used for prepaid and postpaid customer accounts when required by the service.
2. Voice and data service are bundled and delivered to the user as a blended service.
3. Mediation devices from different telecom networks (IN-, IP-based) have to be provisioned and interfaced by the CBS in place.

Although convergence in the sense of item 1 above is in the focus of this paper, we foresee emerging combinations with the other convergence dimensions (blended services, convergent networks through multiple mediation devices).

By convergent rating, charging and billing, we understand corresponding operations

- for any type of service, such as voice, data, multimedia, and content,
- from any type of account, such as postpaid, prepaid and convergent billing accounts, and
- for any type of charging model, i.e., subscription-based charging as well as event-, volume-, time- and reward-based charging.

3.3. Context-aware Charging and Billing

A discussion of the different notions of *context* in the area of pervasive computing systems – which is highly relevant for context-aware mobile systems considered in this paper, is presented in [4]. For the purpose of this article, take the definitions of [5]:

> *Context information* is any information which can be used to characterize the state of an entity (i.e., a person, a place or in general an object) concerning a specific aspect. […] *Context* is the set of all context information characterizing the entities relevant for a specific task in their relevant aspects. […] A system is *context-aware*, if it uses any kind of context information before or during service provisioning.

Following these terms, we define context-aware charging as the process of converting service usage-related data into a monetary-equivalent value under consideration of service-related context information gathered before or during service provisioning.

It remains to specify which context information is relevant for a service. In [6], the following contextual domains have been identified:

1. Location (e.g., user location),
2. time,
3. environmental context (e.g., temperature, light),
4. informational context (e.g., stock quotes, sports scores),
5. application context (e.g., history of visited Web sites or files opened),
6. user context (e.g., health, mood, schedule),
7. group context (e.g., group activity, people around),
8. system context (e.g., network traffic, status of printers), and
9. physical object context (e.g., position/orientation, size, weight).

These contextual domains come with a notion of quality w.r.t.

1. Confidence (a probability of correctness about the sensed or deduced context),
2. accuracy (an error percentage of the sensed or inferred context),
3. freshness (the average time between readings of a certain kind of context, elapsed time since last reading), and
4. resolution.

In order to have a common understanding of the contextual domain elements together with their potential quantitative and qualitative values and thus being interoperable, the goal is to define an *ontology* that can be shared among context-aware services and the related convergent charging services. This ontology could be defined by means of, e.g., the context ontology language as developed in [5], but a suitable instantiation is still an issue of research. As the focus of this article is on convergent charging and billing, we assume in the remainder that all context information required for the intended charging and billing of context-aware mobile services is passed as a list of name/value pairs and that all participants have a common, well-defined understanding of this context information.

4. Relevant Standards

The solution presented in this paper is based on two different standards. These standards are the Parlay X APIs [7,8] and the Diameter standard for credit control [9].

OSA/Parlay comprises open, technology-independent application programming interfaces (APIs) that enable the development of applications that operate across multiple, networking-platform environments. Parlay integrates intelligent network (IN) services with IT applications via a secure and billable interface. The Parlay APIs are designed to enable IT developers to develop applications deployable also in IN environments. The Parlay X Web Services are intended to even more stimulate the development of NGN applications by IT developers who are not necessarily experts in telephony or telecommunications. The Parlay X Specification consists of fourteen parts whereby the most important parts for this paper are Part 6: Payment [7] and Part 7: Account Management [8].

The **IP Multimedia Subsystem (IMS)** is a standardized Next Generation Networking (NGN) architecture for telecom operators that want to provide mobile and fixed multimedia services. Existing phone systems (both packet-switched and circuit-switched) are supported. The aim of IMS is not only to provide new services but all the services, current and future, that the Internet provides. In this way, IMS will give network operators and service providers the ability to control and charge for individual services. IMS uses open standard IP protocols, defined by the IETF. So, a multimedia session between two IMS users, between an IMS user and a user on the Internet, and between two users on the Internet is established using exactly the same protocol. Hence IMS truly merges the Internet with the cellular world; it uses cellular technologies to provide ubiquitous access and Internet technologies to provide appealing services.

The **Diameter** protocol is intended to provide an Authentication, Authorization and Accounting (AAA) framework for applications such as network access or IP mobility. Diameter is also intended to work in local Authentication, Authorization & Accounting situations, as well as in roaming situations. The part relevant for this paper is the Accounting Framework [9].

5. Proposed Solution

To enable reliable online charging and billing operations based on open standards and usable by third party providers, we implemented a number of Web Services in front of Orga Systems' CBS called OPSC® Gold[4].

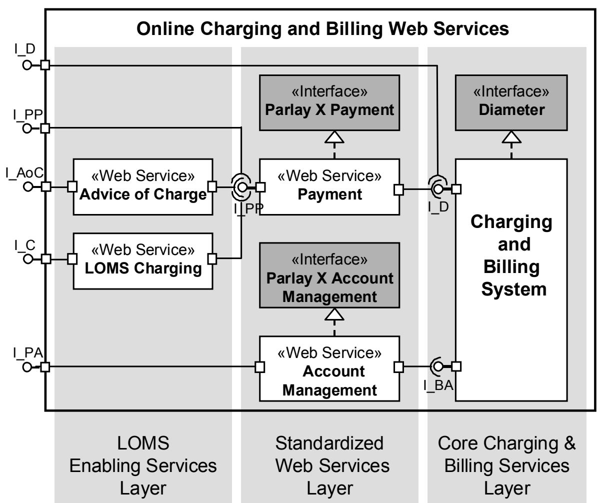

Figure 2: Online Charging & Billing Web Services

Figure 2 depicts an overview of the provided Web Services by means of a component diagram that subsumes all Web Services and the CBS in a single charging and billing component. The CBS already supports a Diameter-conforming charging interface (I_D, see Figure 2) and a proprietary interface for account management (I_BA). These interfaces are used by Web Services for payment (which offers interface I_PP) and account management (I_PA), respectively.

Concerning account management and billing, the interface I_PA provides Parlay X-compliant operations to make account queries, update the balance of an account, and generate bills. Service and Network Operators will use these operations in order to update balances and to configure billing cycles and properties.

Concerning rating and charging, the interface I_PP of Web Service "Payment" offers all Parlay X rating and charging operations and further operations to negotiate and set additional charging parameters not covered in Parlay X (e.g., currency types, volume types, timeouts for charge reservations).

Furthermore, there are two additional Web Services for Advice of Charge (AoC) and LOMS-specific Charging. Note that these two Web Services solely make use of the Web Service "Payment" to contact the backend CBS. Their interfaces I_AoC and I_C provide operations that allow to hand over the actual context of the mobile user. With this provided context information, the Web Services and the CBS can calculate the involved players and how the actual costs for service usage will be shared between these players, like, e.g., the Service Providers, Service Operators, Network Operators, and Mobile Users.

Note that the Parlay X Payment API does not support any parameters to pass context information. However, some contextual information could be obtained by the Parlay Web Services and the CBS themselves, e.g., the current date and time. In contrast to the Parlay X Payment API, Diameter allows to define arbitrary name/value pairs as additional parameters, leading to various proprietary dialects used by the different telecom equipment vendors in the market. This is in fact a major problem for an MNO when integrating third party CBSs that claim to be Diameter-conforming, as adaptations are almost always necessary in practice.

Nevertheless, once the involved parties (i.e., service providers and CBS operator) have agreed on a common context ontology (see Section 3.3), it becomes possible to charge context-aware services usage.

5.1. Advice of Charge

The Advice of Charge Web Service (Interface I_AoC in Figure 2) provides an AoC before the actual service usage and the possibility to set an upper or lower limit for service usage (see Table 1). The provided kind of AoC is able to rate the service usage prior to really using the service [10]. Currently, AoC services only allow to obtain the costs either at service usage set-up (AoC-S), during service usage (AoC-D), or after service usage (AoC-E) [11].

[4] http://www.orga-systems.com/file.php?file=/brochures/OPSC_Gold_en.pdf&type=down

Table 1: Interface I_AoC

`CalculateServiceCharges(userID,serviceID,volume,contextInfo)` Returns the calculated service charges for a specified volume (expressed in, e.g., seconds, bytes) taking additional information about the context into consideration.
`SetChargingLimit(userID,serviceID,amount,notificationType)` Sets a Limit. This limit describes the maximum amount of money a mobile user is willing to pay for using a service. When service usage reaches the specified limit, the user will be notified by the specified kind of notification (e.g., a beep or a direct SMS).

Table 2: Interface I_C

`ReserveServiceCharges(userID,serviceID,volume,contextInfo)` Reserves calculated amount charges on the accounts of all players that have to be charged for using the specified service. The calculation of the charges and the determination of the involved players are based on the provided volume and context information. The operation returns a reservationID for reference purposes in subsequent calls (see below).
`ReserveAdditionalServiceCharges(reservationID,volume,contextInfo)` Reserves *additional* amounts on the accounts of all involved players. Particularly the context information can be different from the original context information provided for the previous reservation, such that there is a need to re-calculate the charges and the newly determine the involved players.
`ChargeReservation(reservationID,volume,contextInfo)` Charges the calculated amount from the accounts of the involved players based on the provided volume and context information. Additionally, credits are performed to turnover accounts of particular players – which again may be determined by the provided context information.
`ReleaseReservation(reservationID)` Releases the reserved charges from the accounts of the involved players.
`ChargeServiceCharges(userID,serviceID,volume,contextInfo)` Directly debits calculated amounts from the accounts of the involved players. Calculation of charges and credits and determination of involved players is performed analogously to the operation `ReserveServiceCharges`().
`RefundServiceCharges(userID,serviceID,volume,contextInfo)` Refund calculated charges from accounts of involved players (e.g., in case of bonuses) based on the provided volume and context information.

5.2. Context-aware Online Charging

First of all, recall that the LOMS-specific Charging Web Service presented here requires a CBS that supports online charging. Basically, the interface I_C builds upon the volume-related Parlay X Payment operations and extends them by additional parameters `serviceID` and `contextInfo`, where the latter is a list of name/value pairs that has to be previously agreed upon between the Service Operator and the CBS operator.

5.3. Deployment and Operation

For the deployment of the charging and billing Web Services, assume that a LOMS Platform Operator operates a CBS. A LOMS Service Operator who wants to use the enabling services for context-aware online charging in his service templates has to make an agreement with the LOMS Platform Operator about the supported features. Prerequisites are that

- each Mobile User has an account in the CBS,
- the LOMS Service Operator has an account in the CBS, and
- the LOMS Service Providers that are customers of the LOMS Service Operator have an account in the CBS.

To support the required features, the LOMS Platform Operator will have to define a dedicated product catalog containing the different services the LOMS Service Operator wants to offer. For this product catalog, usage tariffs and rules will have to be defined in order to enable context-dependent calculations of the charges.

To provide an example, assume an event-based split charging where the service provider bears a part of the costs charged to mobile users when certain conditions w.r.t. the users' context are fulfilled during service usage. In this example, the service provider is operating a department store and wants to offer a service where mobile users are allowed to browse the Internet for free, if they are physically located inside the store and view Web pages of the store's own portal. Additionally, when in the store but accessing other Web pages or contents, the store operator will subsidize 50% of the online costs. Figure 3 shows an example payment flow for the latter case: the platform operator who operates the CBS receives 90% of the paid money.

Correspondingly, there needs to be a product "browsing the Internet" in the CBS with three usage tariffs:

Usage tariff 1: The mobile user has to pay 100% of the online costs. All costs will be debited to the account of the mobile user.

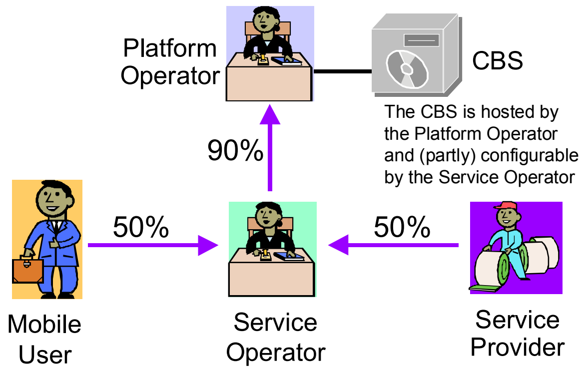

Figure 3: Payment flow for sharing costs

Usage tariff 2: The mobile user has to pay 50% of the online costs. 50% of the costs will be debited to the account of the mobile user and 50% to the account of the service provider.

Usage tariff 3: The mobile user has to pay nothing for being online. All costs will be debited to the account of service provider.

During operation of the service the enabling services for context-aware real-time charging or AoC will be called with the actual context and charging information. The charging information is rated based on the provided context information. In the example, rating selects the appropriate usage tariff. If the mobile user is outside the store, usage tariff 1 is applied. If the mobile user is inside the store, it depends on the actual visited Web page whether usage tariff 2 or 3 has to be applied.

6. Conclusions & Outlook

We see convergent online charging and billing as a promising solution for reliable third party payment operations able to satisfy all involved parties. The corresponding services presented in this article allow context-aware Advice of Charge and charging operations. Summarized, the features are:

1. Provide AoC before an actual service usage.
2. Setting a charging limit allowing a mobile user to define a maximum amount he is willing to pay for a dedicated service usage.
3. Context-aware online and offline charging for service usage.
4. Account management and billing functionality to make account queries, update the balance of an account, and generate bills.

With these features, the presented services are optimally applicable for rating, charging, and billing of context-aware mobile services.

Our future research efforts focus on

- performance evaluation of Web Services for online (real-time) charging,
- evaluation of the service creation and maintenance process for Service Providers, in particular the reconfiguration of deployed services (as proposed in [12]), e.g., in order to change charging rules or required context information, and
- in-depth analysis of the added value of our approach (benefits related to context information).

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