ARCHITECTURE FOR A SERVICE-ORIENTED AND CONVERGENT CHARGING IN 3G MOBILE NETWORKS AND BEYOND

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Abstract

Services will be the economic driver for 3G mobile networks and beyond. For the provision of new services a charging architecture supporting fast and easy integration of new services on the one hand and enabling versatile tariff models on the other hand is of vital importance. In this paper we present a service-oriented charging architecture. The key idea of the architecture is the separation of service-conscious and service-agnostic areas whereas the different areas are configurable by policy rules. A service example is used to demonstrate the operation and flexibility of our architecture.

1 Introduction

In the upcoming mobile landscape, the vision is based on the advent of diverse new services, diversified value chains and competitive business models. All of these will have direct or indirect consequences on the charging functionality of mobile telecommunication systems. First of all, it has to be possible to quickly introduce numerous new services into the system. Additionally, versatile tariff models will have to be supported simultaneously and efficiently. In order to meet these requirements, a future charging system has to be flexible with regard to the easy introduction of new services, capable of an efficient charging of these new services as well as of apportioning the collected revenue among the service providing parties.

In this paper we present an architecture that introduces a new concept for a more efficient and flexible charging. We call our approach *service-oriented* since it allows to charge any combination of services. The term charging is used in a twofold manner. In a more general sense charging refers to the process of raising charges for telecommunication services. In the second and more technical sense the term charging covers all processing steps to translate a certain data record into an amount of money. Although basic services comprise only application, bearer and transport services, a service offered by some provider may be any bundle of these services. Therefore, a service-oriented charging architecture must be suited to combine these service bundles with any kind of tariff or pricing model worked out by the service provider.

Within the context of this paper, accounting is referred to as collecting data about resource usage that comprises gathering, transporting, formatting, and storing data about chargeable events. The data records resulting from the accounting serve as input for charging in the stricter sense, which in turn calculates non-monetary expenses based on the service used and subscriber-specific tariff information. Finally, billing translates these non-monetary units and generates a bill that is charged to the subscriber's account[3]. In case of a so-called online charging procedure, rating is immediately conducted in order to update the subscriber's account in parallel to service utilisation. By pre-processing the gathered data as soon as accounting and charging is conducted, there is neither a need for correlation during billing nor for cost-intensive solutions specific to services without which such a billing level correlation would otherwise not be possible.

The main idea making this possible is the aggregation and correlation of chargeable events already in the course of the accounting and charging process, thereby eliminating the costly and complex necessity to do so during billing. It also makes it possible to conduct online and offline charging procedures and supports pre-paid and post-paid schemes.

2 Shortcomings of today's charging solutions

One shortcoming of existing charging systems for packet-based services in mobile networks is that they lack a flexible concept that allows for an efficient and simultaneous charging of a wide variety of services. Rather, charging solutions have been implemented in a customer-specific way and optimised for the few services known before hand. Often, existing charging systems are not ready to deal with new kinds of services and have to be adapted specifically and massively at service introduction. Especially, online charging procedures have been prone to late modifications because of their special interfaces. This has already led to significant delays before such services were deployed and ready to use, with MMS (Multimedia Message Service) being one prominent example. Current charging solutions virtually have to be tailored for each new service one by one and the existing charging systems have to be modified and enhanced for the service to be introduced. Such a process has been slow and inefficient.

With the introduction of flow-based charging [2], 3GPP has already tried to address this problem. Until then, it was not possible to separately charge services that were using the same GPRS (General Packet Radio Service) bearer. Flow-based charging changed this by extending the capabilities of the GGSN (Gateway GPRS Support Node) to differentiate between data flows belonging to different services on the basis of so called charging rules. These rules not only specify how a flow can be identified but also how it should be charged. Although there is the possibility to dynamically create rules to identify data flows and to add new rules when new services are introduced, flow-based charging does not go far enough. Introducing a new charging solution to the already existing plethora of network entities that create charging data in a 3G system, only adds more complexity to an already complex situation, since it is not clear how all these elements will interact and how extensive correlation work can be avoided. Additionally, having the GGSN do packet filtering and deep packet inspection will reduce the number of subscribers that can be supported by a single network element, i.e. it remains yet to be seen if such a central solution will scale for the task at hand.

As a result, one may conclude that existing mechanisms only tackle parts of the described problems (e.g. also [5, 1]), but there is no overall solution, yet.

3 Architectural Concepts

As shown in Figure 1 the system's architecture is divided into functional areas that interact with each other. In this way the system is split into service-conscious and service-agnostic areas. Since these areas are composed of several distributed functions, they are called *domains* in the following. Our architectural model distinguishes three *domains*.

The *Charging Domain* comprises the entire knowledge about services. For each service to be offered by some provider a tariff model has to be defined and appropriate rules for configuring the system have to be available. These tariff and configuration rules form the charging policy for the respective service. In addition to that the Charging Domain hosts the user accounts for online charging and their management. The processing of charging records - i.e. rating, billing etc. - is located here as well.
While the Charging Domain knows about the services and how they have to be charged the *Authentication and Authorisation (AA) Domain* focuses on the subscriber and his eligibility to utilise certain service categories. All contract and subscription data are located here and allow for identity management.

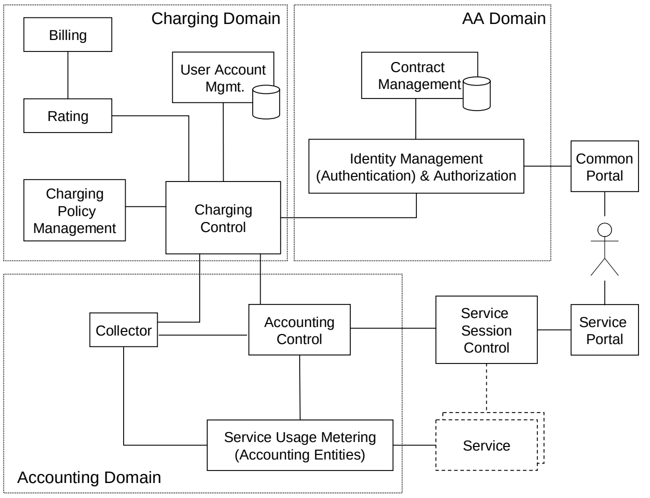

Figure 1: Architecture for Service-oriented Charging.

The *Accounting Domain* is a key component of the system and is responsible for collecting the usage data that are relevant in order to charge a particular service. In contrast to the domains introduced above, the Accounting Domain is agnostic with respect to services and subscribers. The network elements within this domain are configured by means of the rules that are a part of the charging policies.
Last but not the least there is the user him- or herself with a terminal running the favoured application or having an appropriate client installed. Portals provide for a graphical interface to administer subscription data or select and access desired services. Both the Accounting Domain and the Charging Domain are considered in more detail in this paper. The other system components being responsible for authentication and authorisation (AA) and billing also play an important role for the functioning of our concept but are not in the scope of current work.

3.1 Charging Domain

The Charging Domain manages the user and the service context and is therefore in the position to control and supervise the entire charging process. In the Charging Domain functions for subscriber account management as well as for the rating of usage data are located. The Charging Domain draws on the functionality of the AA Domain for purposes of identity and contract management as well as service authorisation. The charging results are either sent to a billing system for offline processing or are used for real-time online charging procedures. These procedures enable the Charging Domain to maintain the subscribers debit account, provide precise subscriber tariff information (advice of charge) and supervise predefined credit limits.
Its main functions as depicted in Figure 1 are now described in greater detail.

Charging Control
Charging Control plays a pivotal role in our architecture. On the one hand, it is responsible for providing all the configuration data required for a successful and efficient

accounting to the Accounting Domain. To do so, it converts charging rules that are related to services, tariffs and subscribers into accounting rules that only refer to the respective accounting task at hand and allow for the configuration of the agnostic Accounting Domain. On the other hand, Charging Control receives the gathered accounting data from the Accounting Domain for further online or offline processing. Besides, Charging Control is the only direct interface between the Charging and the Accounting Domain.

Charging Policy Management
Charging policies describe for which subscribers and services, which tariffs shall be applied. They consist of a set of rules that are applied when their antecedent clauses meet the current situations. They are stored and managed by Charging Policy Management that serves as database for a fast and efficient lookup of charging rules applicable to the requested service, the requesting subscriber and his or her tariff by the Charging Control.

User Account Management
User Account Management is responsible for the management of user account balances either to support an online pre-paid charging scheme or to offer credit limit supervision in combination with post-paid scenarios. This function can be imagined as a highly efficient real-time database with appropriate methods to maintain several counters per user.

Rating
The Rating examines the usage data that are provided by the Accounting Domain via Charging Control, applies the relevant tariff, and finally calculates the charge for the session or service event.

Billing
Billing summarises all functions necessary to produce the customers' bills at the end; nevertheless it is not in the scope of this document.

3.2 Accounting Domain

In the Accounting Domain all data necessary for the charging process is accounted upon request by the Charging Domain. The accounting processes carry out this task and consist of flexible, scalable and extensible mechanisms for efficient usage measurement (e.g. counting of user data packages) and other mechanisms for data consolidation (e.g. aggregation of decentrally gathered data). The Accounting Domain must be understood as an agnostic functionality highly specialised on data collection without any knowledge of subscribers or service tariffs. This becomes possible by a policy-based approach [5] that allows both for a pre-configuration for standard cases as well as a dynamic configuration for the particular accounting task at hand. These processes are controlled by the Charging Domain which passes so called accounting policies down to the Accounting Domain. Based on such policies the accounting entities are configured taking load-balancing aspects into account as described in [4]. In contrast to accounting in the 3GPP context today the presented Accounting Domain is easily extensible by plugging accounting entities with new capabilities to the system. The Accounting Domain comprises three main functionalities:

Accounting Control
The Accounting Control Function (ACF) maintains close control over the entities in the Accounting Domain. Its responsibility is to ensure that the Charging Domain receives the requested information. Selection of the Collector and the Accounting Entities (AE), their configuration and management, and the detection of changes in the networking topology are tasks of this component.

On external events like new charging rules or routing changes or if the session changes, i.e. if services are added or removed from the session, or the session terminates, Accounting Control may reconfigure Accounting Entities or select a new Collector in order to adapt to the changed environment.

Collector
At the Collector the accounting data received from the active AEs is aggregated and forwarded to the Charging Control for further processing. By having collectors distributed all over the network, an efficient pre-processing of the accounting records is possible. Only aggregated information is passed to the Charging Domain which reduces its processing load.

For each service session, a Collector is selected during configuration. The Collector is unique for a particular service session but may change in the course of service provision as a reaction to e.g. a reconfiguration of the service session or changes in the data path. The collector component receives data records from the different AEs and correlates them with the different active service sessions.

Accounting Entity
Accounting Entities are the components which do the actual accounting of resource usage in the network. This accounting at individual network nodes can be driven by various factors depending on the requirements of the service session and be based on information that allows to identify the data flows that are comprised by the respective session. With IP-based networks it is possible to make this identification based on the IP-5 tuple (source address, destination address, source port, destination port, protocol) or flow labels (e.g. MPLS label, IPv6 flow label).

4 Validation by Example

To show the functioning of the devised architecture, we present a scenario that plays during next year's soccer World Cup, where a mobile subscriber accesses Web content with his mobile phone to keep in touch with events. To promote his GPRS offerings the subscriber's operator has made a special agreement with FIFA and other content providers. Not only does he offer a special volume discount on all endorsed content but also takes care of creating a single bill, so that

interested users are not discouraged to access this content because credit card numbers would have to be specified. In return the content providers have adapted their media to the special needs of mobile customers. Additionally, some providers have also added advertisements to their media and offer them at an extra-discounted rate.
In the service installation phase the mobile network operator (MNO) has already configured his charging system for these requirements by adding the according charging policies, so that when subscribers access this special content, they are charged correctly.

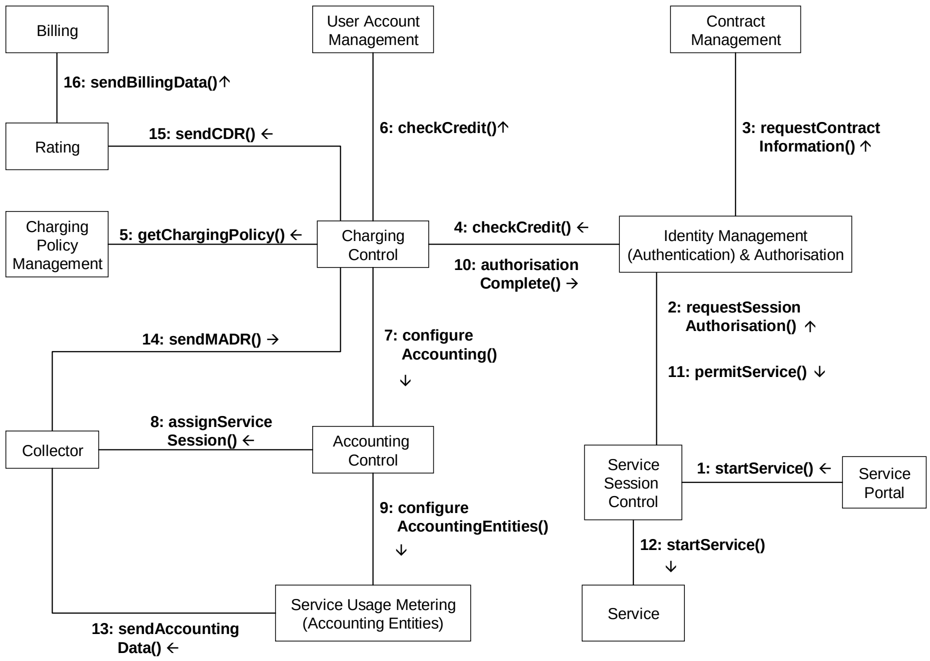

Figure 2: Scenario Interactions.

The steps that take place for session establishment when the mobile subscriber opens the MNO's special World Cup service portal and for service usage after this has been successfully carried out, are shown in Figure 2 and described in the following.

Service Request
(1) The process starts when a subscriber requests service usage via the special World Cup service portal. The service portal forwards the request to the Service Session Control of the requested service, providing information about the subscriber.

Authentication
(2) The Service Session Control requests authorisation for the given subscriber and requested service from the Identity Management component. The session (i.e. service instance) creation does not yet take place at this point, i.e. the result of authorisation is awaited before service provision commences.

(3) In order to obtain tariff information about the given subscriber, Identity Management queries the Contract Management component based on the available subscriber information. As response, Contract Management returns a reference to the tariff specified in the MNO's contract with the given subscriber.
If the subscriber's contract does not comprise the requested service (i.e. he or she may not access this special content), rendering the service is denied by returning a corresponding message to the subscriber's mobile terminal via the Service Portal and no further processing is done in this case.

Configuration of Charging
(4) Based on the acquired information, Authorisation then requests a credit check for the given subscriber based on his tariff.

(5) On receipt of a checkCredit message the Charging Control component first queries Charging Policy Management based on the tariff reference and service at hand. As result the tariff part of a charging policy can be retrieved for the given service, which now allows to calculate the cost for service usage (i.e. the charge).

(6) To prevent over-expenditure or credit fraud, the Credit Control component queries the User Account Management for the given subscriber's current balance/ budget. Based on the returned balance information and the tariff at hand, Credit Control derives whether the subscriber is eligible for provision of the requested service.
If the subscriber's current balance does not suffice, rendering the service is denied by returning a corresponding message to the subscriber's mobile terminal via the Service Portal and no further processing is done in this case.

Configuration of Accounting
(7) After authorising was completed successfully, Charging Control prepares service provision by requesting the Accounting Domain to configure itself based on the accounting policy part of the respective charging policy at hand. Charging Control also passes session information to Accounting Control so that chargeable events generated by the service's provision can be assigned to the correct session.

(8) During accounting configuration Accounting Control first selects a Collector that is used for collecting and aggregating accounting data (Accounting Data Records). In order to correlate the data received during service provision, session information is passed when Charging Control selects the Collector.

(9) As next step, Accounting Control initiates the configuration of the accounting entities. The employed mechanism to achieve this configuration is based on a path-coupled signalling protocol (e.g. [6]) and on a selection algorithm by the help of which one or more accounting entities are determined to do service usage metering. After its completion, references to the accounting entities along the data path are returned, as well as the identifier of the accounting entity/entities that was/were selected for service usage metering.

Authorisation

(10) After being informed about completion of the accounting configuration process, Charging Control reports success to Authorisation.

(11) Authorisation then permits service provision for the requested service. In case of service denial, the reason is passed for being indicated to the subscriber.

(12) Service Session Control then creates a new service session. After its instantiation, service provision is initiated.

Here, the service establishment phase ends. The subscriber is permitted the service and service provision commences.

Since the MNO has provided special charging rules for endorsed sites, the Accounting Domain is capable of differentiating between normal Web content and special content that needs to be charged differently. The accounting and charging activities that are carried out when the authorised subscriber uses the service, are now described:

Service Provision Including Accounting & Charging

(13) During service provision, the selected accounting entities register chargeable events as configured by the respective charging rules. These events are transformed into Accounting Data Records (ADR) that are sent to the responsible Collector for further processing.

(14) The Collector collects all incoming ADRs for one service session, aggregates and correlates them. This results in a Master Accounting Data Record (MADR) that is sent to Charging Control.

(15) Based on the received MADRs Charging Data Records (CDR) are created by Charging Control. These CDRs are then sent to Rating. In the online case, Rating returns the usage cost used to update the subscribers account information and to check for further eligibility for service provision; if the user's credit expires, services provision is stopped

(16) For offline processing, Rating sends the charge for service usage to the Billing component. The Billing component then serves as interface to the Billing Domain that creates the single bill that is sent to the subscriber.

5 Conclusion and Outlook

In this paper, we have presented a new architecture to realise a flexible charging system. This flexibility is attained by using a policy-based configuration of both the charging and the accounting functionalities. The configuration is driven by charging policies that can be defined on different granularity levels. They reach from network as the coarsest, via service, user and session (i.e. a service instance) down to a single packet flow as the finest. It is possible to initiate a pre-configuration for standard use cases or to dynamically configure the Accounting Domain for special services and tariff schemes.

From a user perspective, our approach offers a win-win solution for all concerned parties. Firstly, it allows mobile network operators (MNO) to extend their service portfolio without the problems that are normally brought about by introducing new services thereby opening new sources of revenue for them. Secondly, service subscribers do not have to care about who is providing a service and how they have to pay for service usage. Everything is summarised in a single service-oriented itemised bill issued by the MNO. Thirdly, the same fact allows the service provider to concentrate on service provision and devising new services by delegating their billing processes to the MNO.

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