
An integrated charging, accounting and billing management platform for the support of innovative business models in mobile networks

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Abstract: In the near future, it is expected that mobile operators will offer their subscribers a plethora of services as well as the ability to access value-added services offered by independent providers. However, until this goal is reached, there are several technical issues related to dynamic service provision and charging that have to be tackled.

In order to examine in detail all the attributes of the aforementioned issues, we present the involved players and the prospective business models for flexible service provisioning. Furthermore, we outline the key concepts of such mechanisms and respective interdependencies between business entities, network/communication domains and the charging functionality. We also present the latest efforts undertaken by standardisation bodies to address these issues and the mechanisms that are planned to be deployed. Finally, we introduce a generic integrated architecture for charging, accounting and billing enabling flexible service provision in an open marketplace.

Keywords: charging; accounting; billing; business model.

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1 Introduction

The current technological advances in the mobile telecommunications industry and the internet are about to alter the existing business models [1]. Previously uncorrelated domains are converging into an open market, where it is foreseen that a large number of independent content/service providers will offer their services to mobile users through a limited number of network providers. At the same time, the evolution of existing network technologies and the specification of new concepts, such as network reconfigurability and service adaptability, require new, advanced and holistic solutions in several technical areas. One such area is related to the design and management of new sophisticated functions and protocols to support innovative, flexible and efficient charging, accounting and billing mechanisms.

Traditionally, the charging, billing and accounting schemes used in voice and data communication networks have been quite simple. Users have been mainly billed with a flat rate, based on their subscription and/or the duration of their connection, for either making voice calls or accessing the internet. Although the technology of these networks is quite different, users are mainly receiving the same quality for the services they use. These schemes are expected to be altered soon as a consequence of the technological convergence of these two worlds.

The introduction of the IP in the mobile networks necessitates the design and adoption of new schemes for QoS provision, which aim to support real-time services in a quality acceptable by the users. The deployment of such schemes signals the differentiation among users as well as the service flows and packets exchanged through the network. This differentiation creates the need for new mechanisms that will manage the collection of all information concerning chargeable events and, after the appropriate processing, the application of flexible billing schemes for the users. Moreover, the deployment of advanced charging schemes (e.g. content-based, location-based) requires that the charging records should contain all information related to the chargeable events and in an adequate granularity. We also note that the provision of value-added services

from independent service providers to the users causes the need for advanced billing and accounting schemes.

The need for these new mechanisms has been identified by relevant standardisation bodies working quite actively to develop the appropriate functionality. Groups such as the Working Group 5 of the Third Generation Partnership Project (3GPP) and the UMTS Forum in the telecommunications world, as well as the Authentication Authorisation Accounting ARCHitecture Research Group (AAAARCH) of the International Research Task Force (IRTF) are trying to establish the appropriate functionality and management schemes. However, the different working groups are not always working closely together, nor do they consider the same business modelling concept. As a result, several mismatches are created in the specified functionality and even in the adopted terminology. In this paper, we attempt to summarise this work and propose an integrated charging architecture.

The rest of the paper is organised as follows. In Section 2, the involved players in the service provision process are identified, while the existing and newly introduced business models are described in Section 3. The charging frameworks followed by the standardisation groups and the imposed requirements are presented in Section 4. Sections 5 and 6 address the work undertaken in the realm of internet and future mobile networks accordingly to introduce sophisticated charging mechanisms. In Section 7, an integrated platform for charging, accounting and billing that aims to cope with the emerging requirements and be compliant with the innovative business models is presented. Finally, Section 8 concludes the paper.

2 Involved players in service provision

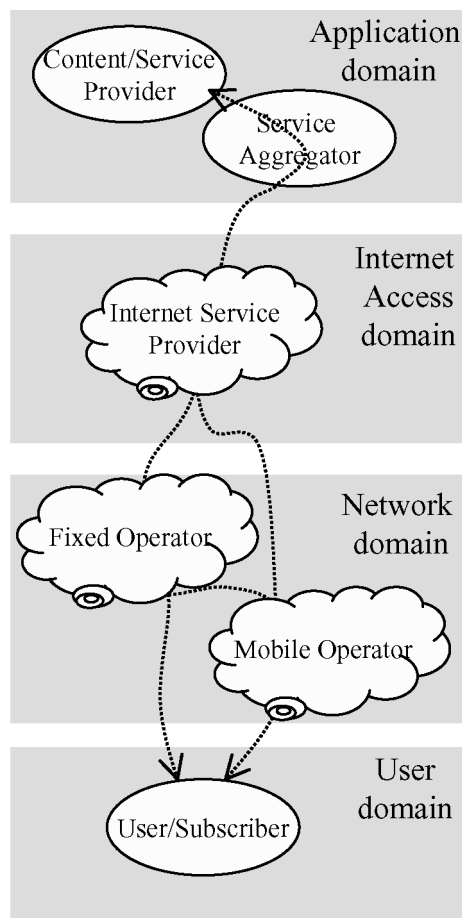
The evolution of 3G enables service deployment and content delivery offered by third-party independent providers over the UMTS infrastructure. This evolution leads to the involvement of additional players in the control and sharing of the cost of a provided service. Overall, from an end-user's point of view, the various roles involved into service provision, which might influence charging of the user/subscriber, are depicted in Figure 1.

These entities are particularly:

- Content/service provider deploys services (content or applications) with added value (weather forecast, maps, on line stock exchange, etc.) to its subscribers.
- Service aggregator is a middleware that enables users/subscribers to be aware of the disposable/available services and categorises services depending on their content, localisation, terminal requirements, etc. An service aggregator can be considered a mobile portal [2].
- Internet service provider (ISP) provides its subscribers with internet access.

- Mobile operator offers bearer and supplementary telecommunications services to mobile users.
- Fixed operator provides telecommunications services to stationary (fixed) users but also its infrastructure could be used as a transport service by other providers (ISP, service providers).
- Subscriber has a contract with the operator and/or provider to be authenticated and charged by the operator and/or provider for services usage. A subscriber could play the role of the user, or give to a number of different entities the ability to access services making use of the transport service provided by network operators.

Figure 1 Involved players in service provision

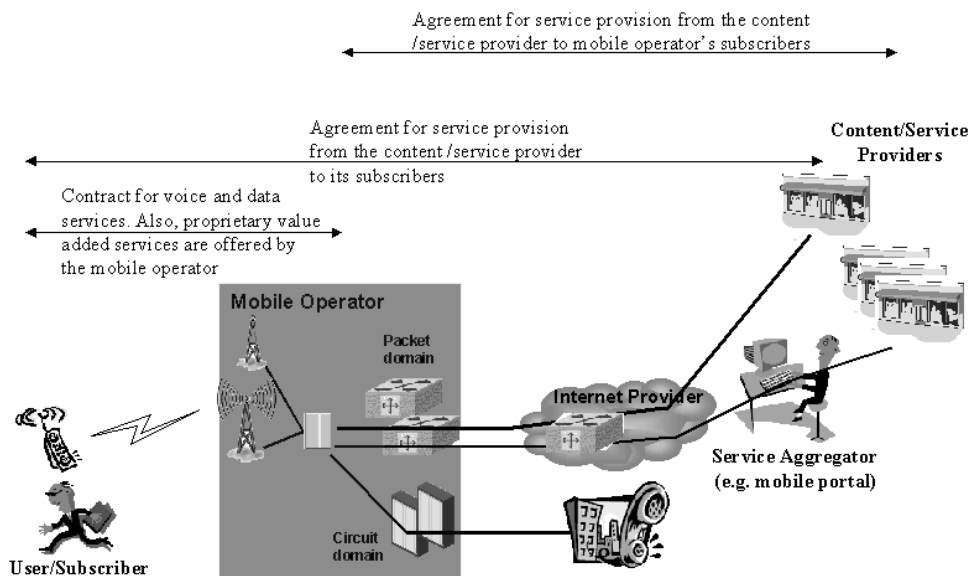


The aforementioned players represent roles that are not necessarily mapped into different business entities. For example, the service aggregator role could be undertaken by the mobile operator, by the content/service provider or by an independent provider. Moreover, in 3G mobile networks, the mobile operator provides GPRS subscribers with internet access, thus covering the functionality provided by an internet service provider.

3 Existing and new innovative business models

Nowadays, to access a service, a user/subscriber initially has to come into an agreement with a network provider. This agreement enables the user to access telecommunication and value-added services provided by the specific operator. Furthermore, so far, for internet access, an additional contract between a subscriber and an ISP is required. This, of course, has been partially altered with the introduction of GPRS, since mobile users can access the internet directly through their mobile operator. Moreover, the usage of services provided by independent entities either is free of charge or is tied to an operator or an ISP. Alternatively, the user has to use his credit card and has to provide his credit card details to non-trusted entities. The existing business models are illustrated in Figure 2.

Figure 2 Existing business models

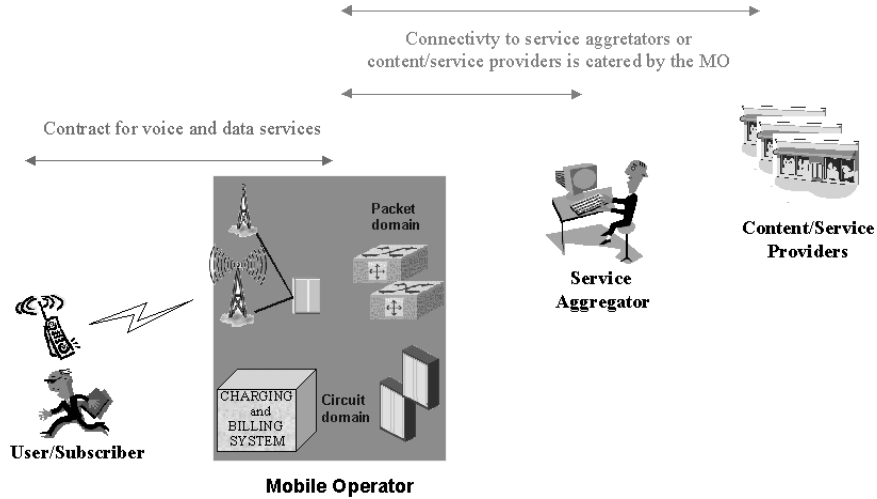


Recent evolutions have enabled the introduction of new contracting models [3]. These models enable users to access various networks and services independently of the owner of the underlying network or the provider of a service.

Three basic business models can be identified [2]:

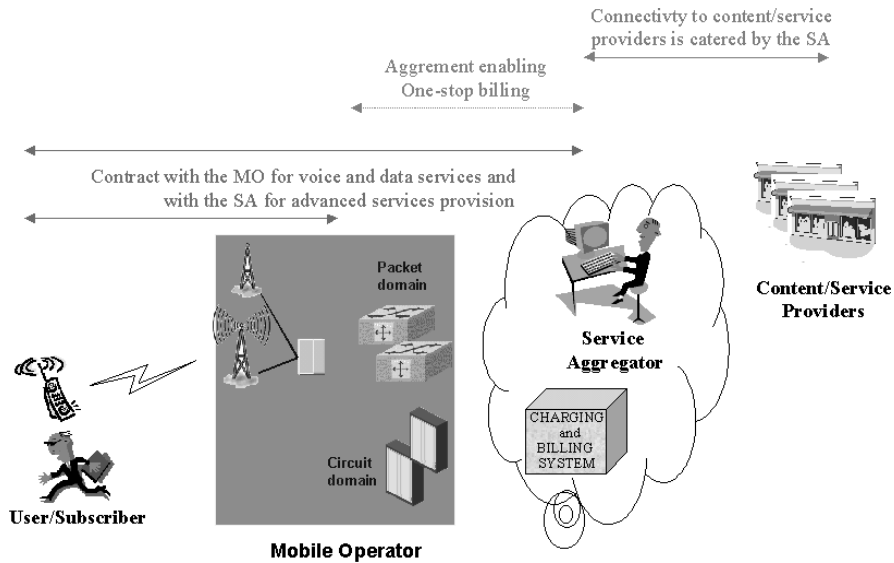
- Network operator centric model (Figure 3), where the user has to come into an agreement with an operator, which is responsible to provide its subscribers with telecommunication services, and value-added services offered by any of the involved players. In this model, the mobile operator incorporates the service aggregator role and is also responsible for collecting charging information and generates a single bill for all charges incurred. This model is close to the traditional one that has been followed for many years.

Figure 3 Network operator centric business model



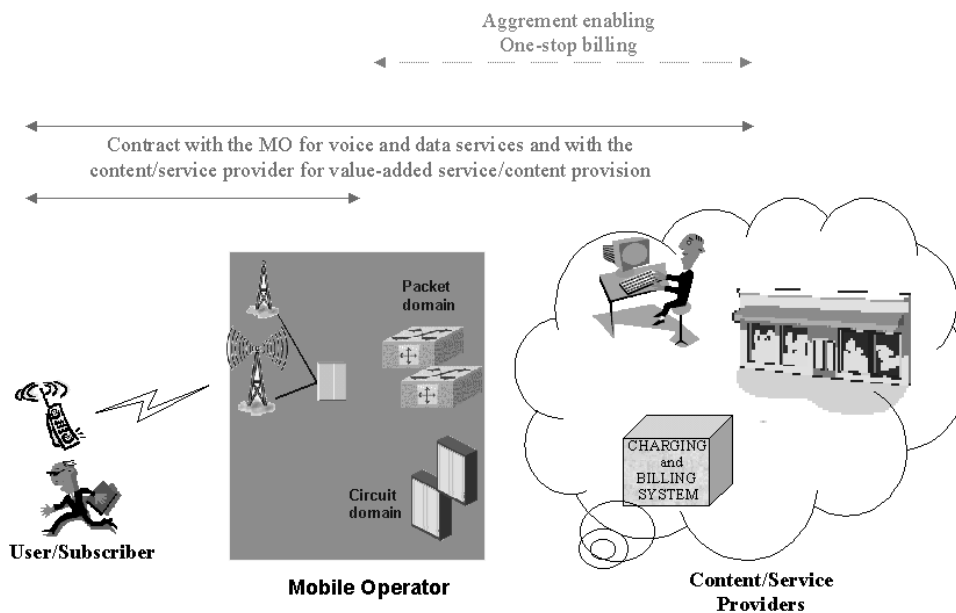
- Service aggregator centric model (Figure 4), where the service aggregator is responsible to provide its subscribers with its advanced services (lookup service, terminal capabilities negotiation, etc.) and access to content and services offered by independent providers. The user should have a subscription with the service aggregator and with a network provider, but for service execution, the service aggregator defines the prices, collects the charging information and charges the user for the transport part as well as for the service and content parts. Another option would be the network operator to charge the user separately for the transport part but this is not compatible with the one-stop billing requirement. The apportioning of revenues between the network provider, the content/service provider and the service aggregator is performed by the former, based on their commercial agreements.

Figure 4 Service aggregator centric business model



- Content/service provider centric model (Figure 5), where the content/service provider comes directly into agreement with a network provider for delivering its content and services. This model is similar to the service aggregator centric model, but in this case the content/service provider takes up the service aggregator role. The users/subscribers are charged directly by the content/service provider, which also defines the pricing and payment policy. Taking into consideration the difficulties introduced by the billing process in the case of the usage based charging model and the necessity for a subscription with each content/service provider, this model can be adopted only in parallel with another one in the case of the most popular services (e.g. MMS images or MP3) [2].

Figure 5 Content/service provider centric business model



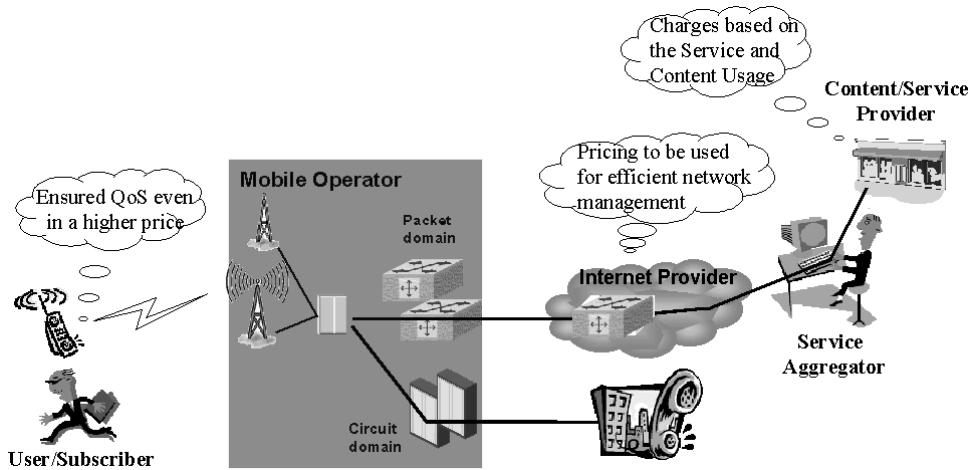
The involvement of new players in the service provision process and the introduction of new models that enables the service provision without the necessity of many contracts and many different bills introduce new requirements regarding the calculation of the charges as well as the apportioning of the incoming revenues.

4 Charging frameworks and imposed requirements

During the past few years, the explosive growth of the internet has been exploited by content/service providers to offer their products to the end-users. The flat rate model that has been adopted to charge people for accessing the network was a simple one and did not require complex systems for monitoring and billing purposes. Content/service providers' revenues were based mainly on advertisements, since their services and content were usually offered to the users free of charge. However, after the development and the introduction of advanced services, new requirements have come up from the

users, the ISPs and the content/service providers. These requirements are addressed in the IETF working groups in several RFCs [4,5], internet drafts [6] and relevant papers [7,8] and is illustrated in Figure 6.

Figure 6 IETF's requirements



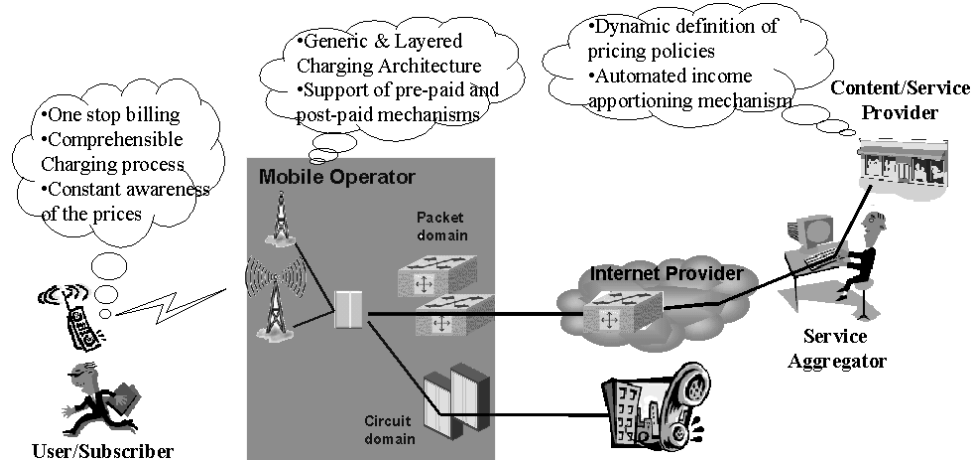
From the user/subscribers' perspective, the main demand is to alter the existing best effort QoS model. A large number of the users are willing to pay additional charges in order to ensure a better quality of the provided services.

At the same time, the ISPs require the introduction of new charging models that take into account the utilisation and sharing of network resources in order to be able to apply efficient network management and to prevent the waste of bandwidth, extending in this way the network capacity. This requirement implies that the network providers should be able to meter the network traffic and the resources consumption.

The content/service providers, on the other hand, require charging mechanisms that will be based on service and content usage. This demand imposes the need for an integrated architecture that will enable the providers to have information on user authentication, traffic monitoring and content-based charging. Taking into consideration that these processes could be complex for some of the content/service providers; it is imminent that outsourcing all or some of these processes would be of interest to them. This requirement creates the necessity for a standard protocol for the exchange of such information.

Regarding the mobile communication industry, revenues were based on the network resource usage. In these networks, it was essential to deploy the appropriate components that collect and process charging information. This information was related only to the duration of a call and the number of the SMS exchanged between users. However, in UMTS networks, users can exchange data in a connectionless way and enjoy value-added services offered by their operators or independent providers. This has created new requirements that are imposed by the involved players. Figure 7 depicts these requirements, which are addressed in several technical reports [9,10] and specifications [11,12] of the UMTS Forum and 3GPP working groups.

Figure 7 3GPP's requirements



From the users/subscribers' point of view, their main recorded demand is the provision of 'one stop billing' for the transport, service and content part of a service independently if these parts are offered by different players (i.e. network operator, independent content/service provider). This requirement implies that the network operator would be responsible for collecting charging data from all players and bill the users. Another requirement is that the charging model should be in a form easily understood by the average users. Also, the users should be constantly aware of the charges to be levied for each chargeable event.

The mobile operators, on the other hand, require a generic charging architecture that can accommodate various charging models (e.g. time-, volume-, QoS-based, flat rate, one-off charge per service, etc.) in order to fulfil not only the traditional business models but also innovative ones. In addition, the selection of a specific charging model could be possibly based on the user and service profile parameters. Another important requirement, imposed by mobile operators, is the support of both pre-paid and post-paid charging mechanisms.

In these networks, a number of players have an active role in the service provision process. To bypass a complicated charging architecture, the mobile operators would prefer a layered charging architecture approach structured in three layers: transport, service and content. The management and processing of the relevant information should be made separately for each layer. Furthermore, different charging models should be possible to be applied on each charging layer.

From the independent content/service providers' point of view, there is an emerging demand that each authorised player should be able to apply dynamically the desired pricing policy for its services' usage. The independent providers should be able to add or modify tariffs for the service and/or content part.

In terms of sharing the incoming revenue between the players (network operators, content/service providers), it is necessary to introduce an automated process, which apportions the incomes, based on the commercial agreements between them. Till now, only simplified mechanisms have been used for sharing revenues due to practical considerations. However, in the oncoming UMTS environment, complex mechanisms

making use of information regarding the resource allocation and usage could and should be possible to be applied.

In the following sections, we present the existing charging architectures and the relevant undergoing activities in the standardisation bodies to meet the aforementioned requirements.

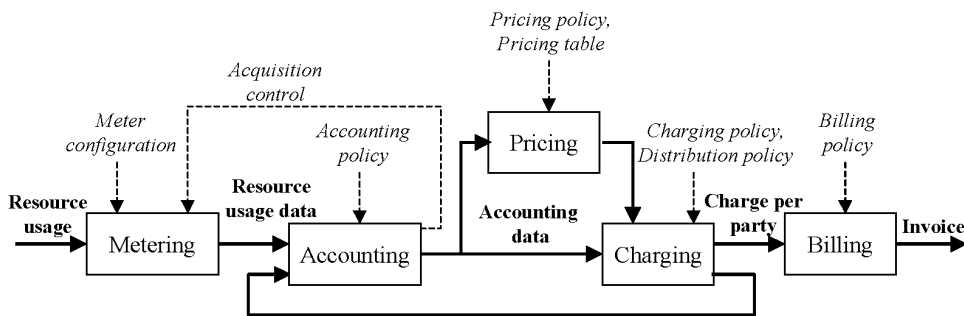
5 Charging, accounting and billing in the IETF

IRTF has organised the AAAARCH to enhance the existing authorisation framework for including authentication and accounting. With reference to accounting, the AAAARCH focuses on policy-based accounting. Apart from this group, another one called ‘Authentication, Authorisation and Accounting Working Group’ (AAA WG) has been formed in the operation and management area of the IETF. The AAA WG is primarily interested in protocols regarding accounting.

The accounting and pricing issues in the internet are also investigated in the framework of European research projects, such as the M3I [13], the Internet NG [14] and the Moby Dick [15]. All these projects are based on the AAAARCH related work.

The AAAARCH group introduces a flexible functional model enabling policy-based accounting [5,6], as shown in Figure 8. The solid lines show the information flow, while the dashed lines depict the configuration actions for policy purposes.

Figure 8 The functional model according to the new approaches in the IETF



Metering is the function of capturing all data related to network resources’ consumption (e.g. volume of exchanged data) and is performed by network devices. According to the AAAARCH group proposal, a meter function can be configured to monitor all flows equally, independently if all data are necessary during the charging process, or it can be configured to collect data only for the flows specified by the metering configuration information. For the configuration of the meter, various parameters have to be set, such as the metering scope that denotes the monitoring characteristics for each flow, the type of information to be collected, the measurement intervals, etc.

After being collected by the network devices in the form of accounting metrics, resource usage data are sent to an accounting server for further processing. The transferring of the accounting data is done with the use of a standard accounting protocol such as Radius [16] and Diameter [17]. The collection of metering data can be initiated either by the network device itself (push model) or by the accounting server, which plays the role of the collector entity (pull model).

The accounting function, which is performed by the accounting server, is responsible for the collection and storage of the accounting data. Accounting may also include summarisation of interim information, elimination of duplicated data and generation and processing of session records. Moreover, session records and their related IDs are also produced and handled. Accounting is also responsible for forwarding these records to other peer entities in the case of roaming terminals. The accounting attributes depend on the applied charging model (e.g. flat rate, session oriented, time or volume based, etc.). According to the IETF standards [18], the attributes contain the identity of the user, the service type, the volume of the transmitted data, the start and stop time for a session, the reserved network resources during a session, etc.

In a flexible model, the accounting server can also be dynamically configured in order to apply different processing of the resource usage data according to the communication type (e.g. voice sessions, http requests, etc.). To this end an accounting policy is required that describes rules for generating, collecting and storing related data.

The pricing function determines the price to be charged for the service usage. To accomplish this task, the pricing function provides the required input to the charging function. The provision of the pricing policy could also be static or dynamic. In the case of dynamic pricing, the accounting function provides the pricing function with the necessary information to compute the corresponding prices. This computation takes into consideration several parameters such as network and service utilisation. In the case of static pricing, this pricing function works autonomously using pre-defined values that are stored in pricing tables [5].

The charging function produces non-monetary cost according to the applied charging policy, which consists of the network resources usage variables (volume, duration, etc.) sent by the accounting process and the service- and customer-specific tariff parameters acquired by the pricing module. In the case of a multiparty communication, the charges are calculated per user according to the specific distribution policy (how the charges are distributed over the involved parties).

The billing function deals with the bill preparation and presentation to the party that is responsible for the payment. This function receives session records or processed accounting data from the accounting function via a Transfer Protocol such as the SMTP, FTP or HTTP. The bill preparation depends on the applied billing policy, which defines the appropriate action (such as computing a special discount for a user, addition of a monthly fee, etc.) during the creation of the actual bill.

6 Charging, accounting and billing in the 3GPP

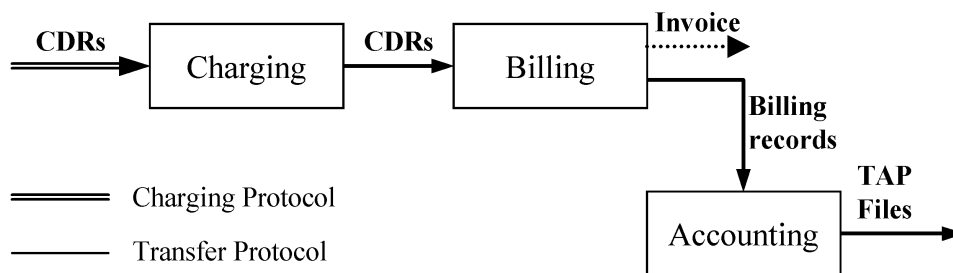
Within the 3GPP, the Working Group 5 is responsible for the telecom management and focuses on charging issues providing new technical specifications and reports. At the same time, the UMTS Forum is also examining these issues and has identified a set of related requirements [2,10].

Charging, accounting and billing issues have also been investigated in the framework of the MOBIVAS European project [19]. MOBIVAS produced an integrated system (named CAB) that collects charging information, generates a single itemised user bill

and apportions the revenue among the involved players. CAB has been designed and implemented taking into consideration the relevant approaches and recommendations of the 3GPP.

Figure 9 presents the existing charging functional model as it is used in today's mobile networks. The related functions applied to mobile networks as well as the similarities and differences of this model with regard to the one of the IP-based networks are described in this section [11].

Figure 9 The functional model according to 3GPP



The charging function collects information related to a chargeable event from several network nodes. The charging information generated by network nodes is structured in the form of a charging data record (CDR) and transferred via standard charging protocols. The charging function is responsible to further process and store temporarily the generated CDRs, to correlate any partial records and transfer them securely to the billing system. The CDRs are transferred to the billing system via a transfer protocol such as the FTAM (File Transfer, Access and Management) or the FTP. The charging functionality is accomplished by two entities, namely, charging gateway functionality (CGF) and charging collection functionality (CCF).

The billing function processes the records coming from the charging functional entity according to the respective tariffs stored in the home location register (HLR) or inside the billing system, and calculates the charge for which the user will be billed.

In the case of roaming users, the accounting function is responsible for calculating the portion that is due to each operator. The billing record concerning a roaming user is forwarded to its home network operator using the 'transferred account procedure (TAP)' and a specific TAP format. The transfer of TAP records between the visited and the home mobile networks may be performed directly, or via a clearing house.

As it can be noticed, several differences to the terminology used by the IETF [4,6] and the 3GPP [9,10] can be identified. The IETF 'accounting' functionality can be mapped to the 'charging' functionality in 3GPP, while 3GPPs' 'accounting' is not used at all by IETF since it is out of the scope of their work. Finally, AAAARCH's 'charging' and 'billing' are mapped into the billing function as defined by the 3GPP.

7 An integrated platform for charging, accounting and billing

The existing approaches in charging management aspects are attempting to cover dissimilar needs and have under consideration different business models while carrying the existing functionalities of quite different network systems. Although the IP is the glue

that will tie together the internet with the mobile networks, the business models and the related charging approaches considered by IETF and 3GPP are diverse in view of the placement and management of the charging functionality.

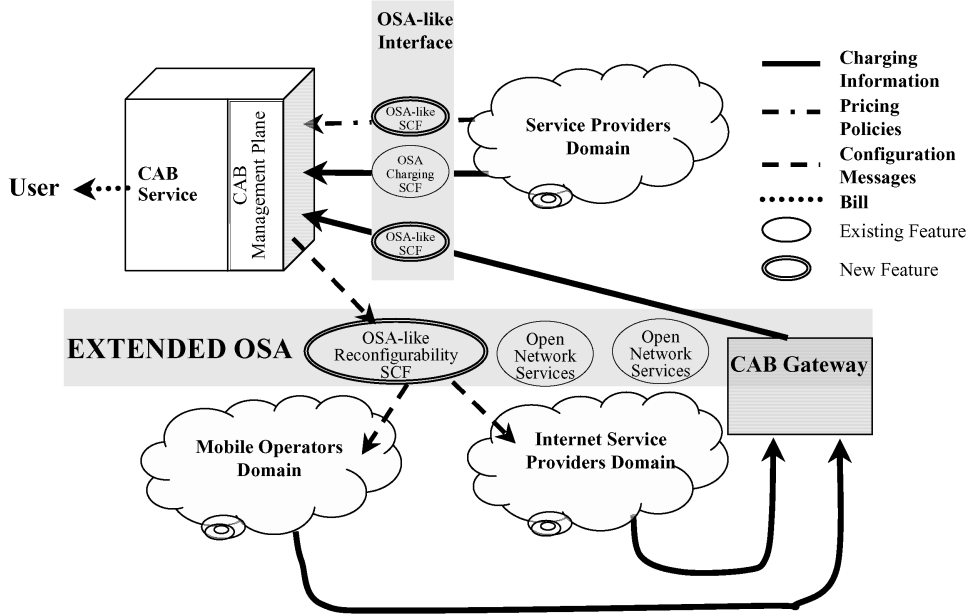
IETF follows a distributed approach, where network providers are involved in terms of transport services and service aggregators and content/service providers are also involved in terms of value-added services and applications. The network operator centric model is adopted by the 3GPP where mobile operators are planning to offer and control transport as well as information services. While IETF's and 3GPP's models tackle efficiently their imposed requirements, they do not provide a holistic solution for all management aspects related to charging for flexible service provision and future communication systems and networks.

Moreover, with the evolution of next-generation mobile systems, the concept of reconfigurability, as the means to achieve adaptability, has been heralded as potentially offering a pragmatic solution for the provision of a wide range of sophisticated services to mobile users [20]. Although reconfigurability is a key enabler to support the convergence of heterogeneous and generalised access, it creates the need to consider additional requirements for managing flexible service provision and charging in reconfigurable environments [21].

Issues related to the management of the overhead and complexity required by reconfigurability, service adaptability, protocol/service downloading, intelligent network and service provision need more detailed consideration, and impose the introduction of additional parameters, policy provision mechanisms, functionality and appropriate application programming interfaces' (API's) specifications. These will be the means for taking into consideration charging events related to protocol and service component downloading (tailored to the user needs and profile), the terminal, network, security and user profiles, etc. Related work has been performed in the framework of the IST MOBIVAS project [22–24], where a generic management scheme for charging, accounting and billing in reconfigurable mobile environments has been introduced.

This scheme has been extended and an integrated platform that will cater for all the involved players has been proposed, in order to avoid any duplication of functionality and enable the efficient handling of these new tasks [21]. This platform introduces sophisticated management and reconfigurable support for charging, accounting and billing procedures as a discrete service. This architecture is presented in Figure 10, and the CAB platform can be under the administrative domain of one of the involved players. According to the adopted business model, the charging, accounting and billing procedures are offered as a discrete service by the responsible business entity [23]. This model assumes that the proposed platform belongs to an independent third trusted party that will have the responsibility and authorisation for the overall charging procedure. This assumption is compatible with any of the aforementioned models.

The platform is able to incorporate the various approaches in charging and the requirements of all the involved players. It supports one-stop billing schemes for the end-users as well as the separation of charging events based on content, service and transport usage information. Moreover, it enables the automatic apportioning of incomes among the players.

Figure 10 Integrated holistic architecture

Note that a charging, accounting and billing management plane provides for the coordination of charging approaches to be applied and for appropriate policy provision. In order to apply different charging requirements, policies and schemes, the use of open APIs among the players that will enable the configuration of network entities for the collection of all required information becomes necessary. For example, the standardised OSA can be used enabling independent players to add application and content charges via the OSA SCF [25]. Furthermore, the introduction and provision of a set of open APIs for the support and management of charging related reconfiguration actions (e.g. pricing policies updates) and the deployment of advanced charging services (online charging indication, current balance of user billing, online provision of information concerning the service profits) are essential [26]. Finally, the proposed platform takes advantage of existing network components and their functionality and is inline with the latest proposals.

A well-defined charging gateway could have the responsibility for collecting all the charging information concerning the network resources usage (i.e. CS, PS and ISPs domain) as well as the services' usage (i.e. IMS and meter entities placed at the edges of the mobile operator network) using standard protocols and interfaces [21]. This gateway is able to handle charging information, related to content plane, coming from independent content/service providers through standard interfaces (i.e. extended OSA interface).

8 Conclusions

The convergence of systems, technologies and networks has resulted in the introduction of increasing degrees of flexibility in service provision and business actors involved in

communication, application and content provision. Alternative business models and respective relationships have been presented in this paper. An important aspect of flexible application and service offering procedures in the various business models is the support of advanced charging schemes.

In summary, the existing approaches related to the management of the charging process seem to lack the potential to fully cover present and emerging requirements in service provisioning. An important drawback relates to the inability to cope with the prerequisites for flexible service provision and download, network reconfigurability and service adaptability aspects of the emerging novel communication systems. This would result in the facilitation of an open market place, where the management for the overall charging, accounting and billing should, in principle, be open to various players (e.g. third trusted parties) and consider requirements and policies from all the involved players.

In this paper, the basic concepts, requirements and activities related to the evolution of the charging, accounting and billing aspects for the support of the forthcoming business models by standardisation bodies were presented. Finally, a generic integrated architecture for charging, accounting and billing with the objective to cope with the increasing requirements and to be compliant with the possible business models was outlined.

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