A platform for charging, billing & accounting in future mobile networks

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***Abstract* - Current technological advances enable the modification of existing mobile telecommunications business models. In future mobile networks mobile users will be able to choose from multiple network operators and service providers. This capability enforces the extension of the existing charging collection information mechanisms and billing systems to assist the oncoming mass service offering by independent service providers. In this paper we present a platform that extends the existing systems to provide for advanced and flexible charging mechanisms and pricing policies.**

***Key-Words* - Service provision, Charging, Billing, Accounting, open APIs**

1 Introduction

The convergence of the internet with the mobile telecommunications world is about to potentially modify the existing business models. This is because mass service deployment and content delivery offered by independent providers over the UMTS infrastructure is now possible. The participation of additional players in the process of service provision includes them in the cost sharing and control of a provided service.

Nowadays, a mobile user should be subscribed to a network operator in order to have access to the network and the value added services provided by the specific operator. The usage of value added services provided by independent entities is either free of charges or the user has to use his credit card for accessing each service, sharing several times this information with non-trusted entities. Similar relations exist between the internet users, the internet service providers and other value added service providers.

The recent technological advances allow however, the introduction of new business models such as the Network Operator Centric Model, the Service Aggregator Centric Model and Content/Service Provider Centric in each of them the name actor has the overall control [1][2].

These new business models require that the existing mechanisms for charging, billing and accounting[1] will evolve. Most likely the new mechanisms will be a compromise between the ones used in the internet and the ones used by mobile operators. However, ongoing efforts on standardization bodies do not converge on the adoption of the same business models [3]. Thus, it is expected that there will exist some duplication of functionality or even that the overall system's capabilities will be more narrow since they focus on specific parts. This phenomenon is in contradiction to the current technical trend of using the IP functionality heavily in the mobile networks as well. Moreover, limiting the capabilities on specific business models that favor some of the existing players will not ease the mass deployment of value added services. Thus, the necessity of a platform for the management of the network functionality to provide advanced and flexible charging mechanisms for different business models seems to be necessary.

In this paper we propose the use of such a platform in the context of a generic architecture. This platform, already prototyped in SDL (Specification and description Language), is based on the related work done in the standardization working groups for layer-based charging, where transport, service and content usage are treated separately [4]. The proposed platform incorporates the functionality of the existing network elements and enables any involved player to dynamically apply different charging requirements, policies and schemes. The standardized OSA/Parlay framework can be used to this end, since it enables third party independent providers to

[1]These terms have not the same meaning in all standardization bodies. In this paper we follow the definition followed by 3GPP where: charging is the process of collecting information about chargeable events, billing is the process of employing specific pricing policies and issuing bills for the users, while accounting is the process of apportioning the income between the operators in the cases of user roaming.

make use of the underlying network functionality without exposing the communication infrastructure to unauthorized business entities [5]. Existing charging entities are extended to support not only content charges but also policy based charging, which allows the application of the appropriate pricing policy according to user, service or session characteristics. Moreover, we propose the introduction 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 such as on-line charging indication, current balance of user billing and provider profit and on-line provision of statistical information.

The rest of the paper is organized as follows. In Section 2, the charging entities incorporated in the existing networks are briefly described. Section 3 discusses the overall architecture for which our platform was designed together with the proposed extensions. Section 4 contains two examples of the charging, billing and accounting functionality offered by the proposed platform. Finally, section 5 briefly discusses the advantages of the platform and concludes the paper.

2 Charging related functionality of the existing networks

Figure 1 illustrates the existing functional entities involved in the charging and billing process in a mobile operator, an internet service provider and a value added service provider.

We start our description from the related components of a UMTS mobile operator [6]. The packet-switched domain of the UMTS is used by mobile users as the core network during the execution of a value added service and content delivery. For the provision of a service to a mobile user over the packet-switched domain the activation of a packet data protocol (PDP) context is required [7]. Each PDP context is a chargeable event and therefore it causes the generation of charging information. Both the packet-switched domain support nodes, i.e. the serving GPRS support node (SGSN) and the gateway GPRS support node (GGSN) generate charging information in form of charging data record (S-CDR and G-CDR, respectively) related to PDP contexts [8].

The charging information provided by the SGSN concerns the radio network usage, while the GGSN provides charging information regarding the external data network usage. Both of them generate charging information about the usage of the packet-switched domain network resources. A charging identifier, called charging ID, is generated by GGSN at PDP context activation and transferred to the SGSN. During a PDP context, a sequence of partial CDRs are produced by both GPRS Support Nodes (GSNs), the charging ID is used for the correlation of these partial records.

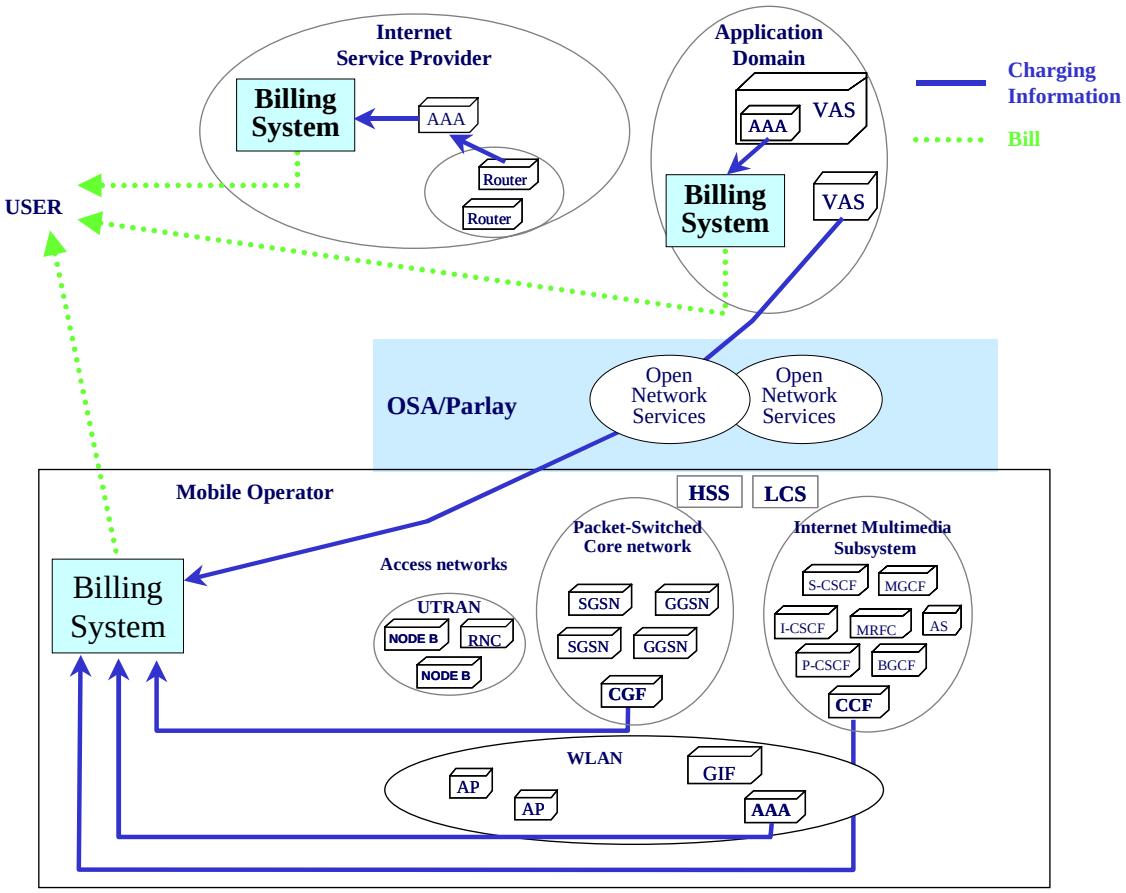
The CDRs are collected by the charging gateway function (CGF) via the standardized Ga interface using the GTP' charging protocol [9]. The CGF can be implemented in a separate network element, the charging gateway (CG) or may be distributed to several physical entities (i.e. integrated in the GSNs).

The CGF transmits the processed CDRs to the operator's Billing System using a proprietary protocol depending on the billing system. The recommendations by the 3GPP are the usage of the FTP and the FTAM protocol but there are not strictly specified, since there are a lot of variations among the existing Billing Systems.

The CGF acts as a storage buffer for real-time CDRs collection and is able to perform consolidation of CDRs and pre-processing of their fields, filtering of un-required fields, and adding of operator defined fields.

In case a mobile user accesses a WLAN system its network elements are able to provide usage data [10]. In case of the tight coupling interworking between UMTS and WLAN, there is a function, GPRS interworking function (GIF) in the WLAN that makes the SGSN consider the WLAN a typical radio access network in the overall UMTS infrastructure. The GIF is connected to the SGSN via the standard Gb interface and the data traffic passes through the GSNs. Therefore, the charging information provided by the SGSN and the GGSN is enough for the calculation of transport charges. In case of loose coupling interworking, the WLAN is used as an access network complementary to the UMTS but it is connected to the GGSN via the standard Gi interface as an external IP network. That means that the data traffic does not pass through the GSNs and therefore they are not able to provide charging information. In this case, the AAA architecture of the WLAN system is used in order the mobile user to be authenticated and the charging information (in form of accounting records) to be produced. The WLAN uses the same subscriber and service databases (HSS) with the UMTS for retrieving information necessary for the authentication and the billing process. Furthermore, the accounting records generated by the AAA are sent to the operator's billing system to calculate the charges.

The IP multimedia subsystem (IMS) has been recently introduced by the 3GPP in order to enable provisioning of IP-based real-time multimedia services including voice over IP over the packet-switched domain and is based on the session initiation protocol (SIP) [11]. The fundamental core network elements of the IMS including the required call session control function (CSCF) for the establishment of sessions are able to generate charging records related to these sessions in form of CDRs. The proxy-CSCF, the serving-CSCF and the interrogating- CSCF generate CDRs for all the SIP session they are involved. In case a SIP session is destined to the public switched telephone network (PSTN), the breakout gateway control function (BGCF) and the media gateway control function (MGCF) are also involved and they produce CDRs records for these session events. The multimedia resource function controller (MRFC) generates CDRs related to session bearer processing resource utilization (e.g., transcoders, bridges, etc.) and the application server (AS) when acting as an AAA proxy.



AAA	Authentication, Authorisation and Accounting	I-CSCF	Interrogating-Call Session Control Function
VAS	Value Added Service	S-CSCF	Serving-Call Session Control Function
OSA	Open Service Access	BGCF	Breakout Gateway Control Function
UTRAN	UMTS Terrestrial Radio Access Network	MRFC	Multimedia Resource Function Controller
RNC	Radio Network Controller	MGCF	Media Gateway Control Function
SGSN	Serving GPRS Support Node	MRFC	Media Resource Function Controller
GGSN	Gateway GPRS Support Node	AS	Application Server
CGF	Charging Gateway Function	CCF	Charging Collection Functionality
HSS	Home Subscriber Server	WLAN	Wireless Local Area Network
LCS	LoCation Services	AP	Access Point
P-CSCF	Proxy -Call Session Control Function	GIF	GPRS Interworking Function

Fig. 1: Existing charging related functionality

The CDRs generated by the IMS core network element are collected by the charging collection function (CCF) via the standardized Rf interface using the IETF Diameter protocol. The CCF is a logical function equivalent to the CGF but also is able to validate, combine, aggregate and consolidate the received charging information, to generate partial records (when it is necessary), to remove duplicated charging data as well to support load sharing, redundancy, high availability and efficient management of the generated CDRs. Note that the charging information generated by the IMS network elements concerns the service plane and concurrently the packet-switched core network elements provide charging information for the transport plane.

The home subscriber server (HSS) is the main database of a UMTS network containing all subscription-related information for the home subscribers. This information is used to support call/session handling by the network entities but can also be used to enable an intelligent billing process. The HSS could be considered as an extended home location register (HLR), which also may contain an AAA Server for handling the respective procedures.

The location service (LCS) is the enabling technology provided by the network operator, which enables the provision of location-based services. The LCS should be able to identify and report in a standard format (e.g., geographical co-ordinates) the current location of the user and to make the information available to the mobile user, network operator, VAS providers and service/content providers. The location information can also be used for location-based charging, location aware content delivery,

emergency calls, etc.

The ISP providing its users with internet access incorporates an AAA architecture, for authentication of its users and gathering of usage data regarding its network resources consumption and generation of accounting records [12]. The IETF protocols, Diameter or RADIUS, are used in the AAA architecture for the transmission of charging information[13]. The ISP may apply the flat rate pricing model or a usage-based one. In case of usage-based model the ISP incorporates a billing system for the calculation of the charges.

In the application domain there is a wide range of services defined and deployed by independent VAS providers. Till now, the VAS are provided either free of charges or the user has to charge his credit card. In second case, the VAS provider can include AAA architecture in order to authenticate, authorize, meter IP traffic and charge its users. Moreover, the VAS providers can submit their content charges to the operator's billing system using the OSA/Parlay charging API [14].

The OSA/Parlay is a generic framework that enables the rapid creation of value added services by third party independent providers over different types of networks. Specifically, the OSA/Parlay is the specification of a set of open, standards and network-independent APIs that enables authorized service providers to control a selected range of network capabilities. The open network services offered to authorized entities concern mobility and location information management, call control and content based charging. The OSA/Parlay charging API allows the submission of content charges.

From the above presentation it is easy to identify that currently, the different business players deploy their own charging related functionalities. Thus, there is not only duplication of functionality but it is quite difficult to mass deploy new services due to the static relations between the physical entities. Furthermore, one of the new requirements by the users is to have one-stop bill for service execution. Obviously, such requirement is quite difficult to fulfill.

Another issue not covered in the existing charging related components is that in the UMTS networks non-SIP services are not measured with the appropriate granularity. This is because information about non-SIP services is aggregated in the information of the PDP context they belong to. Thus, even though a PDP context may contain multiple flows the system cannot distinguish them if they are not SIP sessions.

An interesting characteristic in future mobile systems is that the mobile terminals will be capable to connect to different access technologies, even on the move and when having active connections. This means that vertical handovers between different operators even in same country will be possible (e.g., transferring active connections from a UMTS operator to a WLAN hotspot operator to receive higher transmission rates). In such situations a more automated accounting system is necessary between the operators.

Finally, an important issue is that in existing systems dynamic policy charging cannot be employed. In this way, when a pricing policy for a user, service or content needs to change, it usually is a task involving several business players and network components. In the following section we propose extensions to the existing components to cater for these shortcomings.

3 Proposed additional entities for charging

Figure 2, illustrates the proposed architecture where additional entities are introduced capable of providing integrated charging, billing and accounting.

In this architecture, a mobile user will be able to access value added services through heterogeneous access networks (e.g., UTRAN, WLAN, HIPERLAN) belonging to the same or different operators. The internet connectivity will most probably be offered by the mobile operator but a user will also be able to access the internet through other players such as WLAN hotspot operators.

Taking into consideration that for non-SIP services it is not possible to collect the necessary information for service charging, we propose metering devices (MDs) to be placed at the edge of the operators' network for monitoring the IP flows. The MDs should export IP flow information in a standardised way; this information should be in a standard format e.g. IPDRs. To provide flexibility and efficiency, and contribute in avoiding bottleneck at the edge of the network, the introduced MDs are dynamically configurable, which means that they provide usage data only for flows specified in the configuration policies. The functionality of MDs is under the supervision of the MD reconfiguration manager, which is responsible for their configuration with regard to the traffic monitoring and reporting functionality. With the appropriate software extensions, the role of the MDs can be performed by existing products (e.g. NeTraMet [15]or Cisco's NetFlow [16]). An alternative solution could be the deployment of the IPmeter approach [17], where all traffic is monitored by a device that is not involved in routing tasks.

In order to have a single logical interface between the charging involved network elements and the platform for the charging records transmission, we introduce a charging accounting and billing gateway (CABG). This executes a first correlation of the collected chargeable events and transfers them to the CAB Service. The entities that collect and process charging information concerning the usage of network resources (i.e. CGF and AAA) and the services' usage (i.e. CCF and MDs) support different protocols and interfaces. The CABG receives the charging records using the respective protocols over the existing interfaces, correlates the records related to a specific chargeable event and transmits it using an open standard API (OSA-like interface) to the CAB service.

The CAB service can be considered as a discrete service offered to mobile users. Figure 3 presents the functional entities that comprise the CAB service. The proposed platform was designed taking into account the related work done in the standardization working groups and incorporating the functionality of the existing network elements.

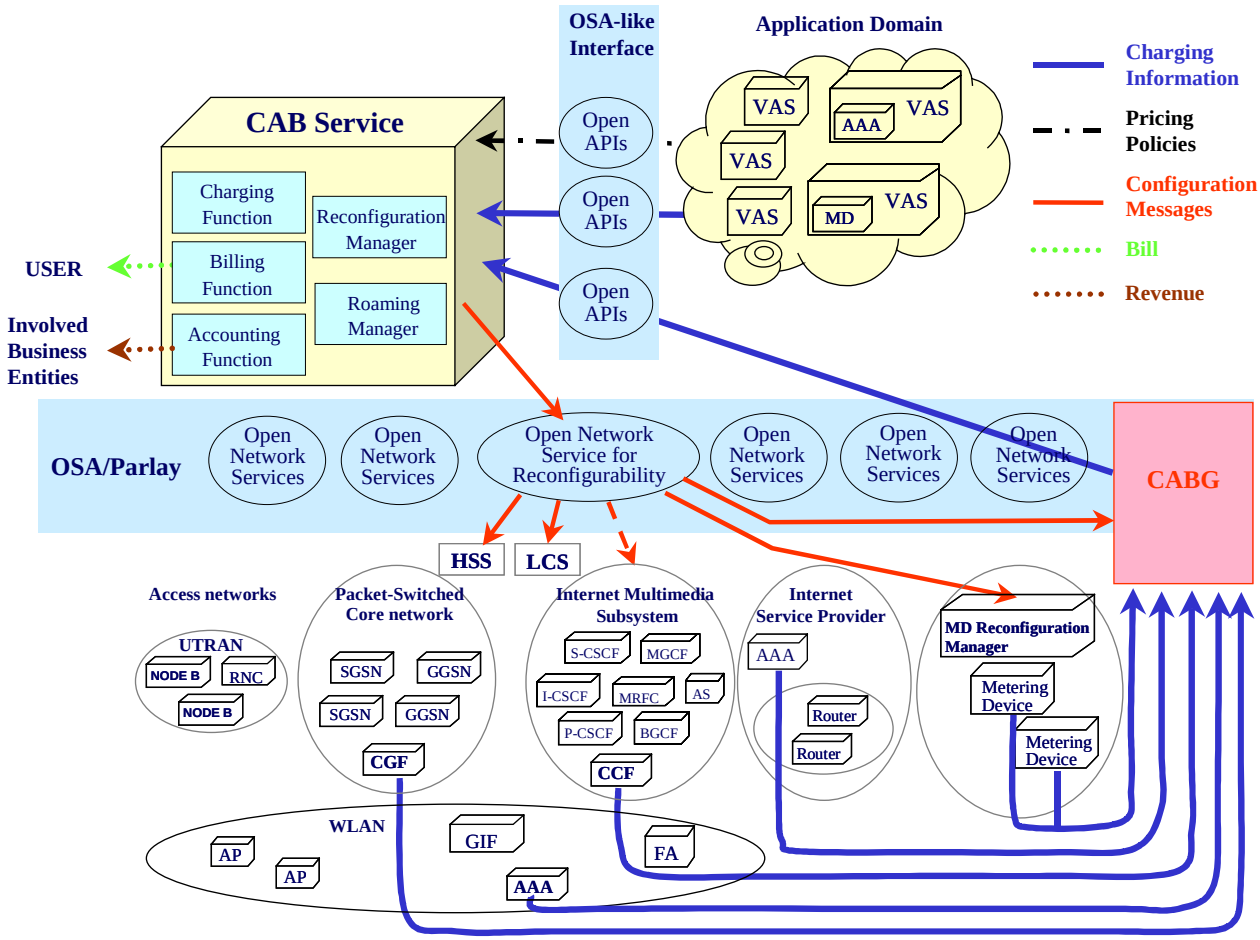


Fig. 2: A platform for Charging, Accounting and Billing

In particular, it comprises the following modules:

The Dispatcher module receives all the messages and forwards them to the appropriate functional entity.

The Charging module receives and processes charging information (i.e. CDRs, accounting records, IPDRs) from the network elements via the CABG. Furthermore, the charging process enables the authorized independent providers to submit their usage data. Based on the applied layer-based model, the charging information and usage data are correlated processed. After this step transport and service records are generated. Moreover, it provides authorized entities with the ability to add content charges through the existing OSA/Parlay charging API and generates content records.

The Billing module applies the pricing policies to the transport and service records in order to calculate the charges. The applied pricing policy depends on user, service or session characteristics and can be different from layer to layer. In addition, the billing process includes the content charges and produces a bill requiring payment.

The Accounting module is an automatic procedure for sharing of charges and revenues between involved business entities.

The Reconfiguration Manager module includes intelligent mechanisms for identifying the particular high-level requirements of the VAS and mapping them to appropriate reconfiguration actions on the underlying network infrastructure. It enables independent providers to define the pricing policy dynamically through an open interface of the extended OSA/Parlay framework.

Roaming Manager is responsible for the process of the charging records concerning roaming users[2]. The applied pricing policy is based not only to the user, service and session characteristics but also to the business agreement between the home and visiting network.

In emerging business models, the application domain may contain a plethora of value added services offered by independent providers. Given the possibility of the existence of AAA architecture and MDs in the VAS infrastructure, an independent service provider can generate accounting records or usage data on its own, or completely outsource the charging and billing process to the CAB service. The VASs are able to communicate with the CAB service through open APIs, submitting usage records and charges and even defining pricing policies for their services usage.

In the next section we illustrate part of the CAB's functionality based on specific usage scenarios and their respective Message Sequence Charts (MSCs).

[2]With the term roaming user we mean a user, who is not subscribed to the CAB service or to a mobile operator cooperating with the CAB service.

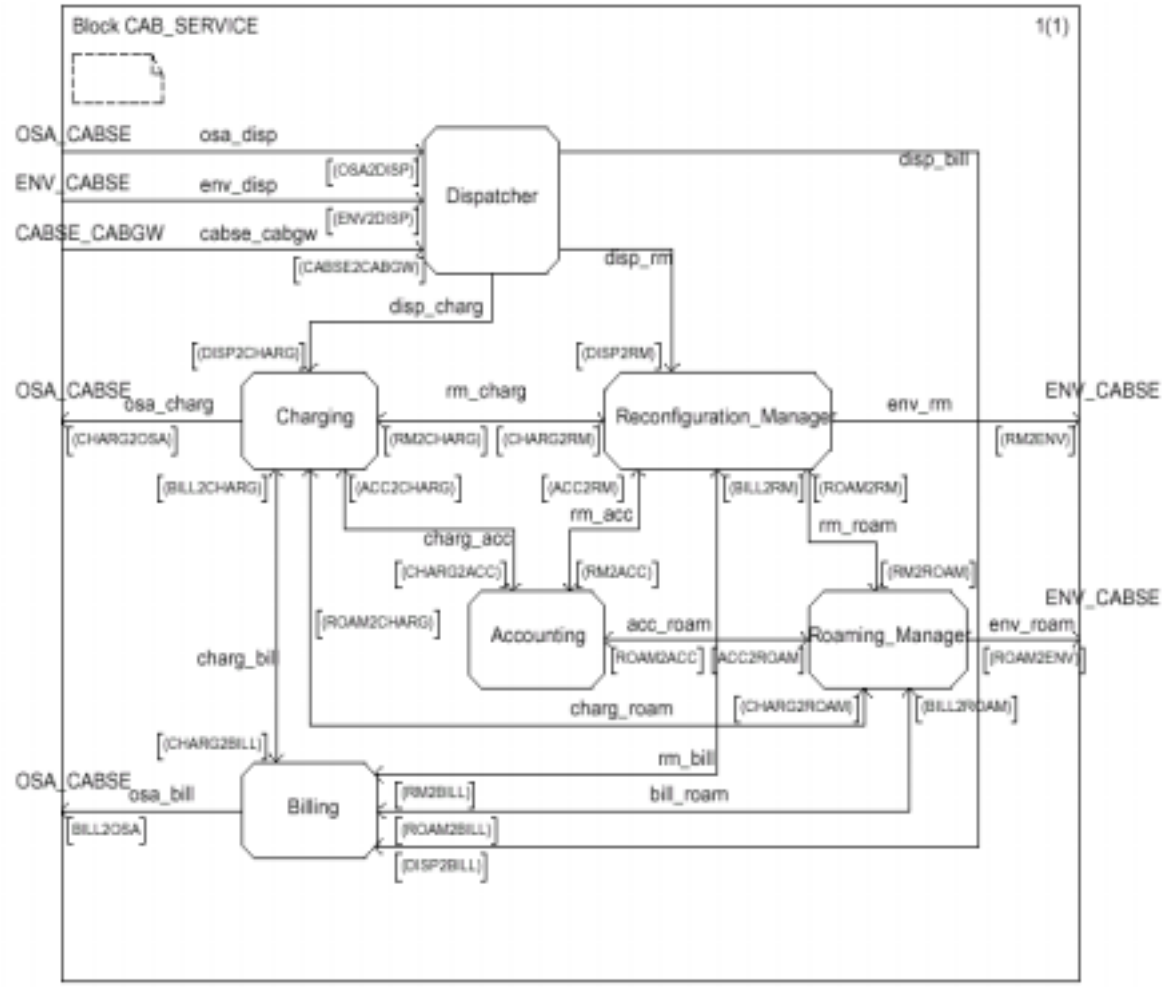


Fig. 3: CAB service functional entities

4 CAB's functionality examples

In this section we present the functionality of the overall platform during the execution of two scenarios. For the shake of simplicity, the MSCs do not contain the messages exchanged by the underlying network's components to the CABG.

The first scenario illustrated in figure 4 deals with the charging, billing and accounting process during the execution of a non-SIP service. In this scenario the user requests to be informed on specific intervals about the charging status for the service. Moreover, the VAS provides the CAB with his own based charging information (content) and can ask the CAB for its current profits for a specific service.

More specifically, a user, while executing a non-SIP service, requests (ON_LINE_CHARGING_ INDICATION) to be informed of the charges during the service execution by providing the user identity (imsi, user_ip, user_port), the VAS identity (vas_ip, vas_port) and the charge unit that defines when an indication should be sent to the user.

The charging module receives the request (through the dispatcher) and asks from the billing module to notify it when a certain limit is reached (EVENT_ NOTIFICATION). During the execution of the service the CABG sends charging information (CHARGING_RECORD) collected by the underlying network elements, such as the CGF and CCF, to the charging module. The charging records are CDRs or IPDRs, and are correlated by the charging module based on the user IP address, user_port, the Access Point Name, the VAS's IP and port. This module generates a TRANSPORT_ RECORD and a SERVICE_RECORD that are sent to the billing module. The VAS through the OSA/Parlay charging interface may send its content charges (DIRECT_CREDIT_AMOUNT) to the charging module as well. The charging module correlates this information with the one received by the operator and notifies appropriately the billing module.

The billing module calculates the transport, service and content charges by applying the appropriate pricing models to the received information. In case a certain limit (charge unit) is overcame, then the user is notified (REPORT_EVENT_NOTIFICATION).

Since the billing module notifies (APPORTION_ REVENUE) the accounting system with all the required information (transport, service and content charges) to apportion the revenues between the players, it is quite easy for them to check whenever they want on their profits (CURRENT_PROFIT_REQ).

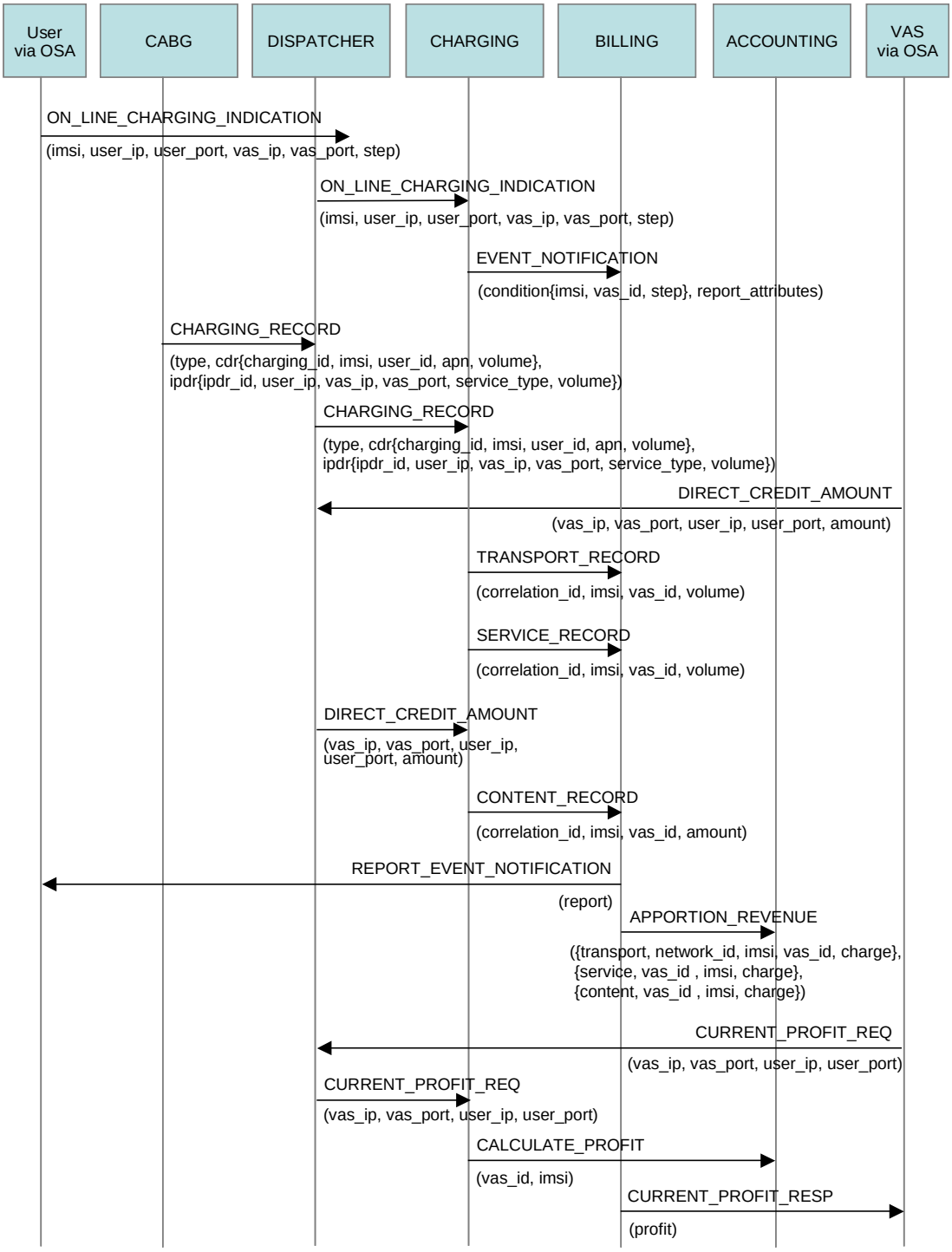


Fig. 4: Charging, billing and accounting process

The second scenario illustrated in figure 5 describes the registration of a new VAS and the necessary configuration action of the CAB service and the MDs.

The VAS provider asks from the CAB to register a new VAS (VAS_REGISTRATION) providing its identity details (i.e., vas_ip, vas_port) and the applied pricing policy. The dispatcher module forwards the request to the reconfiguration manager that through the extended OSA/Parlay framework (METERING_UPDATE) configures the MDs to monitor the appropriate IP flows. The reconfiguration manager also notifies the billing module for the pricing model and tariffs of this service (PRICING_POLICY_UPDATE). In case the VAS provider wants to modify some of the elements of the VAS (i.e., either vas identity details or the pricing model) it can notify the CAB at any time (VAS_UPDATE).

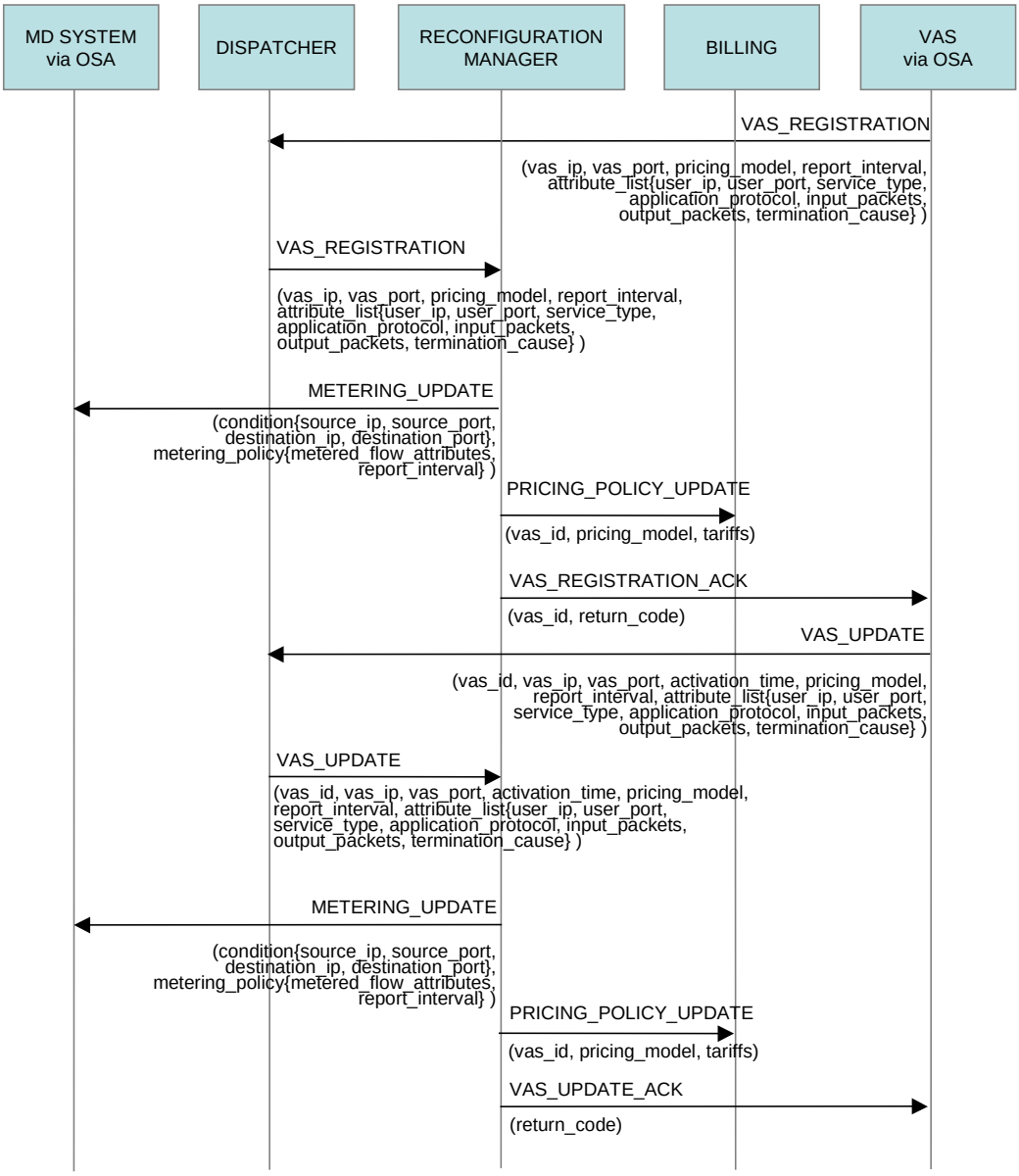


Fig. 5: VAS registration and update

5 Conclusions

By summarizing, the paper proposes an open platform for charging, accounting and billing. It incorporates various charging functionalities enabling sophisticated management and reconfiguration actions for charging purposes.

The platform has been designed to be compliant with any of the emerging business models. Its functionality can be on the administrative domain of any existing physical entity (e.g., operator) or third party independent provider. The platform enables the dynamic reconfiguration of the deployed pricing policy, while provision for using advanced charging billing and accounting services (e.g. on-line charging indication, current balance of user billing, on-line provision of information concerning the VAS profits, etc.) has been taken.

The platform distinguishes between transport, service and content chargeable events, and correlates this information with the service and user profile as well as the location of the user, enabling the enforcement of flexible and advances business models.

The platform also supports roaming users, while it has been design to automatically apportion the revenues between the players in a secure way. Finally, one of the key characteristics of the platform is that it supports on stop billing per service. Such a platform could serve as a common basis for the homogeneous development of charging functionality for new services.

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