Middleware platform for the support of charging reconfiguration actions

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Abstract - **The reconfigurability control aspects and charging information management are very important issues for the emergence of advanced service provision in 3G systems and beyond. This paper describes the charging related features of a proposed middleware platform which enable flexible service provision, flexible charging, customized billing and reconfigurability control The required extension of the OSA/Parlay framework in order to support charging reconfiguration actions are also well defined.**

Key-Words - **Reconfigurability, Charging, Billing, Open Interface**

1 Introduction

With the emergence of 3G mobile communication systems, aspects related to flexible service provision, intelligent and customised charging [1], as well as location aware service [2] and data management have been identified as key enablers for the support of advanced and novel service offerings to mobile users.

Fixed, wireless and data networks are converging and customers are demanding affordable services and applications that work seamlessly across different network domains and different devices [3]. Network operators are trying to differentiate themselves from their competitors by offering new revenue-producing, value-added services (VAS) to hold on to existing customers and to attract new ones [4].

The business models to be adopted are encompassing the accommodation of third party Value Added Service Providers (VASPs), which will be able to offer their services through an operator's network under the respective business agreements. These services will enrich the service offerings provided currently mainly by the operators and will enable the mobile users to have access to a plethora of mobile services and applications [5]. The challenge for network operators is to attract and engage third-party application providers while protecting their networks from harm. By using middleware service platform it is envisioned [4] that network operators will be enabled to open their networks safely, as well as to reduce the complexity involved in delivering applications developed by third parties over mobile networks.

With the evolution of 3rd generation mobile communications as well as the imminence of 4G systems, the reconfigurability concept has been heralded as potentially offering a pragmatic solution for the provision of a wide range of sophisticated services to mobile users [5]. The most significant near term impact of reconfigurability is likely to be in the field of service and applications innovation, as a tool to allow rapid and flexible service customization and new degrees of operator differentiation. Contrary to the application-specific mobile system design for 2nd generation systems, the potentials for flexible and adaptive service offerings that can be supported by the introduction of reconfigurable mobile systems and networks pave the path for advanced service provision schemes. Several efforts and standardisation activities have been undertaken towards the introduction of mechanisms and systems to support reconfigurability in various layers [6][7][8]. In the application level, a very important issue is the introduction of an integrated flexible service provision and reconfigurability control platform. In such a middleware platform, critical aspects of the overall functionality introduced are the charging and billing management mechanisms and respective interfaces and reconfiguration actions support.

Moreover, it becomes apparent that intelligent charging and customized billing of services offered to mobile users is a basic requirement for advanced and customized service offerings [9]. The services offered by the various VASPs will engage various pricing policy schemes [10], which should be provided dynamically to the charging process [11]. Charging information related to the user profile and preferences will also have to be encountered at the billing process. The separation of charges between the transport, service and content plane becomes necessary in order to apportion the revenues between the network providers, the VASPs and the content providers. The complexity involved in all these issues has to be handled in an intelligent and integrated middleware platform.

The reconfigurability control aspects and charging information management in a coherent manner is a very important issue for the emergence of advanced service provision in 3G systems and beyond. A critical point in the introduction of such a middleware platform is the provision of open APIs [12][13] to enable third party services and service providers to have access to network functionality and respective reconfiguration actions [4].

This paper describes the charging related features of the integrated middleware platform and their functionality for flexible service provision. The functional entities presented meet advanced requirements for intelligent charging information management and customized billing.

The rest of the paper is organized as follows. In Section 2, the overall architecture of the proposed service provision middleware platform together with the proposed additional entities to the underlying network are briefly described. Section 4 describes the charging features of the middleware platform. Section 5 presents the proposed extension of the OSA/Parlay framework for supporting charging reconfiguration actions. Section 5 contains two examples of the charging reconfiguration actions enabled by the proposed platform. The main conclusions are drawn at the last section of the paper.

2 The Proposed Service Provision Middleware Platform

The proposed Service Provision Middleware Platform (SPMP) illustrated in Fig. 1 mediates between the VASPs and network operator in order to provide VASPs and end users with service provision facilitation services.

The SPMP has been designed to offer [5]:

- Dynamic Service Deployment to ease VAS introduction and access
- Service Discovery taking into account terminal capabilities, user profile data, user location, etc.
- Advanced Charging, Accounting and Billing service allowing dynamic introduction of new pricing policies, reconfiguration of existing ones, on-line charging indication, on-line provision of information concerning the service profits, etc.
- Network reconfiguration, based on the location of the subscribers and the associated user preferences included in the user profile, enabling location-based charging
- Location-sensitive service deployment, discovery and execution
- User notifications for the available policies, restrictions, tariffs and reconfigurations that are associated with the current location of the user or might take place due to the location update that occurred

The SPMP supports policy-based mediation, and allows a high degree of customization and personalisation.

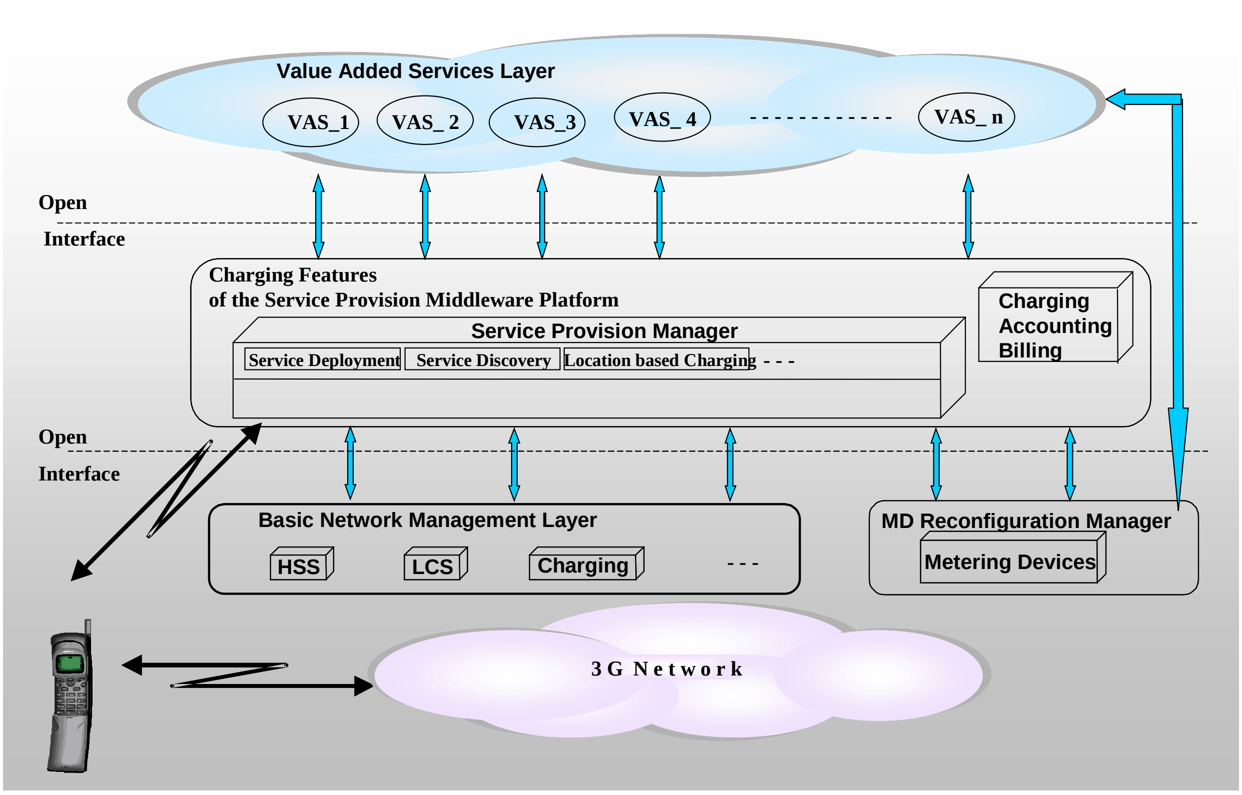

Fig. 1: The proposed service provision middleware platform

Furthermore, the features supported by the SPMP enhance the potential of application and service introduction and provision to mobile users by independent VASPs. Access to the SPMP's services shall be offered to application providers through open APIs. Therefore, application developers do not need knowledge and awareness neither of the underlying basic network services and their interfaces, nor of the SPMP implementation details. The complexity of the service deployment is to a large extent moved from VASPs to the SPMP service platform. Service and underlying network independence are achieved by applying an open service deployment model.

Advanced innovative features, relevant to the charging and billing issues management, are introduced in order to enable dynamic introduction of new pricing policies, reconfiguration of existing ones, on-line provision of VAS revenue balance and users balance to the VASPs and production of a single itemised bill for each user.

Fundamental requirement for intelligent and dynamic service provision is the introduction of open middleware platform that administratively may be situated and managed by entities independent from the network operator. Therefore, interactions among the features of the platform and Basic Network Elements (e.g. HSS, LCS, etc.) should take place through open network interfaces. Various industry initiatives, such as OSA/Parlay [12][13], address the introduction of open network interfaces to third party providers. Common to all these architectures is the provision of a Basic Network Management Layer by the mobile operator, which act as gateway (mediator) between third parties and provided basic network services. Hence, in order the SPMP to access the network services offered by the underlying network infrastructure, interaction with the Basic Network Management Layer is required. By accessing the standard open network interface provided by the Basic Network Management Layer, the SPMP is then able to build its services (e.g. charging and billing service) based on network features and functionality offered by the network operator.

Provided that the underlying network supports open interfaces to access the basic network services, the SPMP can:

- Access the subscribers' profiles stored in the Home Subscriber System (HSS) of their home network
- Access the terminal device capabilities information
- Access the Location information of the end users provided by the Location Server
- Access the applicable network capabilities (e.g. performance data for total network and various network nodes, traffic load on various radio access parts, etc.)
- Access the Charging Service Capability Feature (SCF) of the network for addition of content charges
- Access the Push or the Messaging Server (SMS or MMS) of the network for the notification of the end users

Flexible, advanced and reconfigurable charging service requires the incorporation of new flexible and reconfigurable devices in the underlying network architectures for collecting, monitoring and metering the IP flows and associated application layer data that concern the usage of VAS. Metering Devices (MD) of this type complement the existing network infrastructure enriching it with the ability to provide personalised, policy-based, QoS management, as well as application layer information (e.g. for charging purposes), to the involved players. Most of the interested players will be situated at Third Party domains and should be inclined to reconfigure the Metering Devices and apply their metering, monitoring and QoS policies. To this end, it seems ineluctable the enhancement of open interfaces provided by the Basic Network Management Layer for accessing the network services in order to allow the reconfiguration of the introduced Metering Devices especially for charging purposes.

The Metering Devices (MDs) functionality includes filtering of IP traffic, monitoring of specific flows, metering of the associated data volume and QoS provisioning. These functions are performed by examining transport and application layer information in addition to the network layer data used by conventional IP routers (each service should be identified by the IP address and port of its service part). In the proposed architecture the MDs are located at the edge of the connectivity network of the Network Access Provider so that they process all traffic between VASPs and users. To provide flexibility and efficiency, and contribute in avoiding bottleneck at the edge of the network, the introduced MDs are dynamic configurable, which means that they collect metering data only for flows specified in configuration policies [14][15]. They are configured by the SPMP and authorised VASPs to monitor, meter and provide QoS to specific IP traffic flows that correspond to service usage. The collected metering data is formatted into appropriate records, the IP Data Records (IPDRs), and sent to the CAB for further processing.

The functionality of MDs is under the supervision of the MD Reconfiguration Manager, which is responsible for the policy-based configuration and reconfiguration of the MDs. Since it is proposed MDs to be included into the standard network infrastructure, their services should be provided to the VASPs and other peer network components (e.g. the reconfiguration manager of the SPP) through a standard API. Detailed analysis of the proposed open APIs and associated methods, provided by the MD Reconfiguration Manager for MDs reconfiguration, can be found into the section that follows. The MD Reconfiguration Manager mediates between authorised entities and MDs to securely grant the MD services to the respective parties. Since reconfiguration of MDs is policy based, communication with the MDs is built upon the common protocols for policy provisioning such as the COPS [16] or COPS-PR [17]. The MD Reconfiguration Manager maps all incoming calls on the aforementioned open interface to the appropriate COPS messages for interacting with MDs.

In this paper we propose the enhancement of existing open network services with functionality related to:

- Dynamic configuration of Metering Devices for monitoring specific IP flows and collecting only the necessary metering data related to service usage
- Reconfiguration of Metering Devices when the service parameter, the metering policy or the meter granularity changes
- Imposition for collecting the metering data immediately in specific cases

By accessing the aforementioned network services and combining the results accordingly, the SPMP may satisfy some standing requirements namely network integrity and the ability to charge for service access.

Moreover, by accessing the open network functionality and services and using them intelligently, the SPMP provides the flexibility and customisation required by network operators, VASPs and end users.

3 Charging Features of the Service Provision Middleware Platform

The Charging, Accounting and Billing (CAB) module is responsible for the overall control of the charging process, providing advanced services to VASPs and end users. To elaborate, the Charging, Accounting and Billing (CAB) module collects charging information, applies the appropriate pricing model, calculates the portions that are due to each business entity and produces a single itemised bill to each subscriber. The CAB service depicted in Fig. 2 comprises the following functional entities:

- The CAB Service Capability Feature (SCF) is the functionality offered by the CAB service that is accessible via the proposed open APIs. It enables authorized business players to register new services to the CAB service, to refine the parameters of a registered service, to define pricing policies dynamically, and to submit charging records. Additionally, it provides authorized entities with advanced charging services such as location-based charging, on-line charging indication, current balance of user bill and on-line provision of statistical information. The CAB SCF incorporates the well-defined Charging SCF for content charging [18].
- The Charging module receives and processes charging information from the network elements via the CABG and the usage data and content charges from authorized independent providers via the CAB SCF. Based on the applied layer-based model, the charging information and usage data are correlated and processed. After this step transport, service, and content records are generated.
- 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.

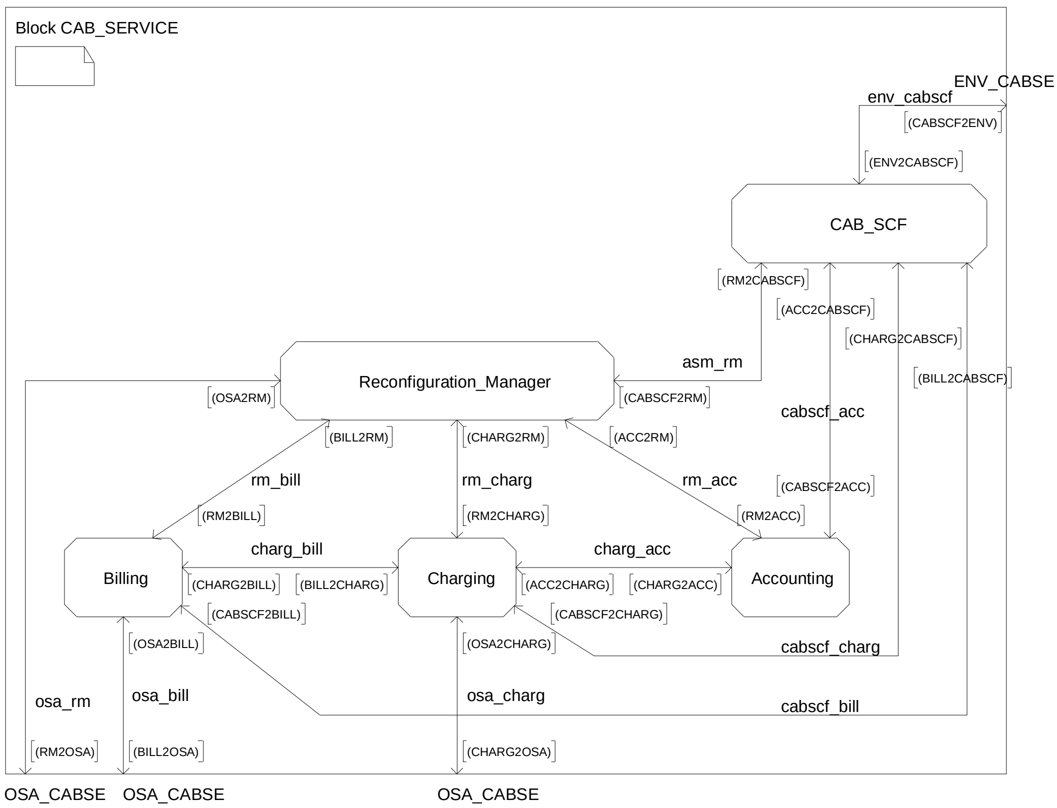

Fig. 2. Internal modules of the CAB service

- 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 business players and mapping them to appropriate reconfiguration actions on the underlying network infrastructure. Specifically, in case of service registration it configures the underlying network elements to monitor the related IP flows and produce usage records according to the applied metering policy. Then, based on the specific pricing policy it configures the billing and accounting modules accordingly. Furthermore, it supports the dynamic modification of the services parameters and the applied pricing policies reconfiguring the aforementioned modules appropriately. Finally, it configures the charging module to generate charging sensitive alerts when the charging information meets some conditions, so that it provides the authorized and subscribed entities with specific event notifications (e.g. modification of tariffs).

In order to have a single logical interface between the network elements related to charging and the CAB service 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 the charging information concerning the usage of network resources (i.e. CGF and AAA) and the services' consumption (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 them using an open standard API to the CAB service.The CAB service reuses the existing functionality of the underlying network by collecting the Charging Data Records (CDRs) generated by UMTS network nodes [19][20]. More specifically, on the one hand there is the Charging Gateway Function (CGF) [9][19], which processes and manages the CDRs, generated by the SGSN and GGSN and related to the utilisation of the packet-switched domain. On the other hand, the Charging Collection Function (CCF) [9][20] provides charging support for the IP Multimedia Subsystem (IMS) subscribers by processing the CDRs generated by the IMS' nodes (e.g. CSCF, MRFC, etc). Both CGF and CCF forward the CDRs to the CAB over the Ga interface. In generic case that the SSMP platform resides in the third trusted parties domain, the CAB module should be authorised by the mobile network operator to receive CDRs generated by the underlying network infrastructure. Additionally to the CDRs, the CAB receives IPDRs generated by the MDs and related to the VAS usage. The IPDRs, apart from calculation of charges, are also used by the CAB for the retrieval of specific information, such as the services that are currently being executed by a specific user.

Additionally, the CAB provides advanced charging services through open APIs in order to enable independent VASPs to configure the applying pricing policy dynamically, to retrieve statistical information concerning their services usage, to add content-based charges and to be informed about the current status of their VAS revenues.

The CAB service provided by the SPMP enables:

- One-stop billing
- Calculation of charges by subdividing them into three charging layers (i.e. transport, service, and content)
- Application of various pricing models according to the service profile, the user profile and the location of the user
- Dynamic reconfiguration of applicable pricing model for specific service, specific user or combination of them
- On-line information provided to the VASPs with respect to the current status of their revenues and the users' balance
- On-line charging indication provided to the users with respect to their charges
- Provision of statistical information regarding the current VAS usage (e.g. the users that currently execute a specific service, or the services that are currently being executed by a specific user)

4 Extension to Open Interfaces for Supporting Charging Reconfiguration Actions

As already mentioned, the reconfiguration actions should take place using open APIs to network functionality provided by the Basic Network Management Layer. We propose the enhancement of the set of open APIs (e.g., OSA/Parlay), which should be made available to the SPMP by the underlying network infrastructure and functionality. An important impact of the enhanced APIs support would be the reconfiguration of MDs. To this end, the open interface provided to the SPP by the mobile operator should be enhanced to accommodate a new service capability feature (SCF), namely the Reconfiguration SCF. The Reconfiguration SCF provides the SPMP with the ability to perform reconfiguration actions on the MDs.

The class diagram illustrated in Fig. 3 shows the application interfaces for reconfiguration purposes.

We assume the Reconfiguration Manager of the CAB service has already discovered the Reconfiguration SCF. As a result, the CAB service has received an object reference pointing to an object that implements the IpMDReconfigurationManager interface. In order to use the open interface, the Reconfiguration Manager creates a local object implementing the IpAppMDReconfiguration Session interface. Following, it is able to order the creation of a session and call any method provided by the IpMDReconfigurationSession object.

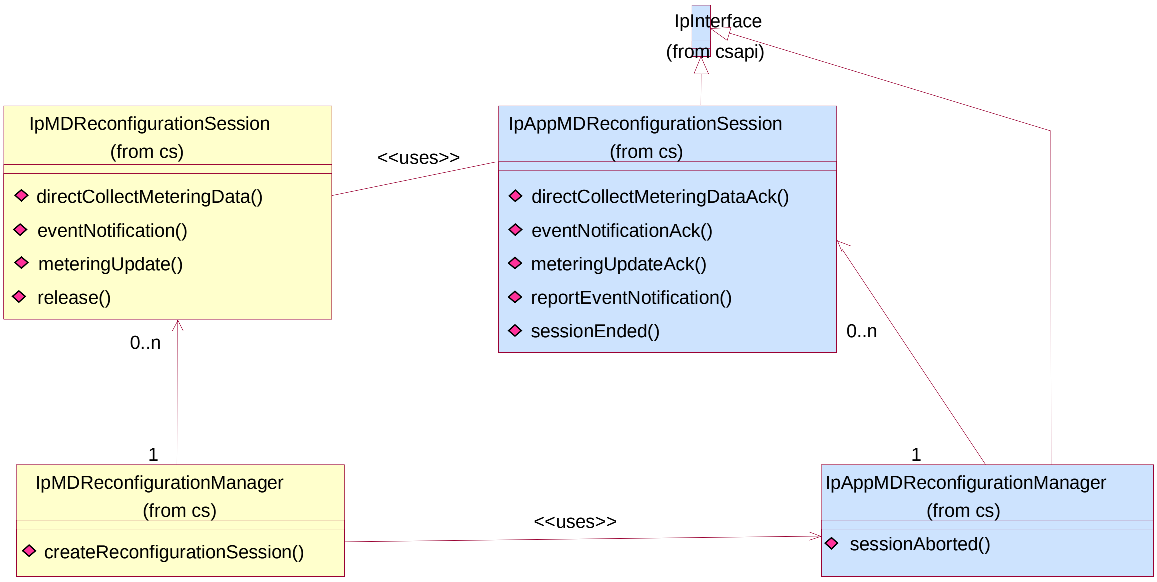

Fig. 3. The Class Diagram with the proposed methods for reconfiguration

The introduced methods enable:

- Stimulation of the MDs in order to close and send immediately the metering data records (IPDRs) concerning a specific service, a specific user, or a specific IP flow, implemented by the method: directCollectMeteringDataReq()
- Request to receive notifications whenever a specific event occurs. It defines the condition of a specific event as well as the requested reported parameters, implemented by the method: eventNotification() and the report transmission is implemented by the method reportEventNotification()
- Dynamic configuration of the MDs in order to start or stop monitoring of IP flows in case of registration or de-registration and modification (e.g. QoS policy, meter granularity, metering policy), of an application/service respectively, implemented by the method: meteringUpdate()

5 Charging reconfiguration actions examples

In this section we present a part of the functionality of the charging features of the SPMP and the respective charging reconfiguration actions with the execution of two indicative example scenarios. The first scenario illustrated in Fig. 4 describes the registration of a new VAS and the necessary actions for the configuration of CAB service and MDs.

The Message Sequence Chart (MSC) (derived from the simulations that have been performed following the SDL specification [21] of the SPMP functionality) depicts the required interactions among the involved functional entities.

The VAS provider establishes a session with the CAB service (CREATE_CAB_SERVICE_ SESSION) in order to register a new VAS (VAS_REGISTRATION). The submitted request includes the VAS identity details and the applied metering and pricing policies.

The CAB SCF forwards the request to the Reconfiguration Manager that, in turn, establishes a session (CREATE_RECONFIGURATION_ SESSION) with the Reconfiguration SCF of the extended OSA/Parlay framework in order to configure the MDs (METERING_UPDATE). The Reconfiguration SCF triggers the MD Reconfiguration Manager (CONFIG_INSERT_REQ) to configure the MDs to monitor the appropriate IP flows. The configuration of the MDs by the MD Reconfiguration Manager is achieved using the appropriate COPS messages that are not illustrated in the MSC for the shake of simplicity [17].

Following, the Reconfiguration Manager informs the Billing module (PRICING_POLICY_UPDATE) and the Accounting one (APPORTIONING_POLICY_UPDATE) about the pricing model and tariffs for the new service in order to be able to calculate the charges and to apportion the revenues respectively.

As soon as the reconfiguration actions have taken place successfully, the CAB service acknowledges the registration to the VASP (VAS_REGISTRATION_ ACK).

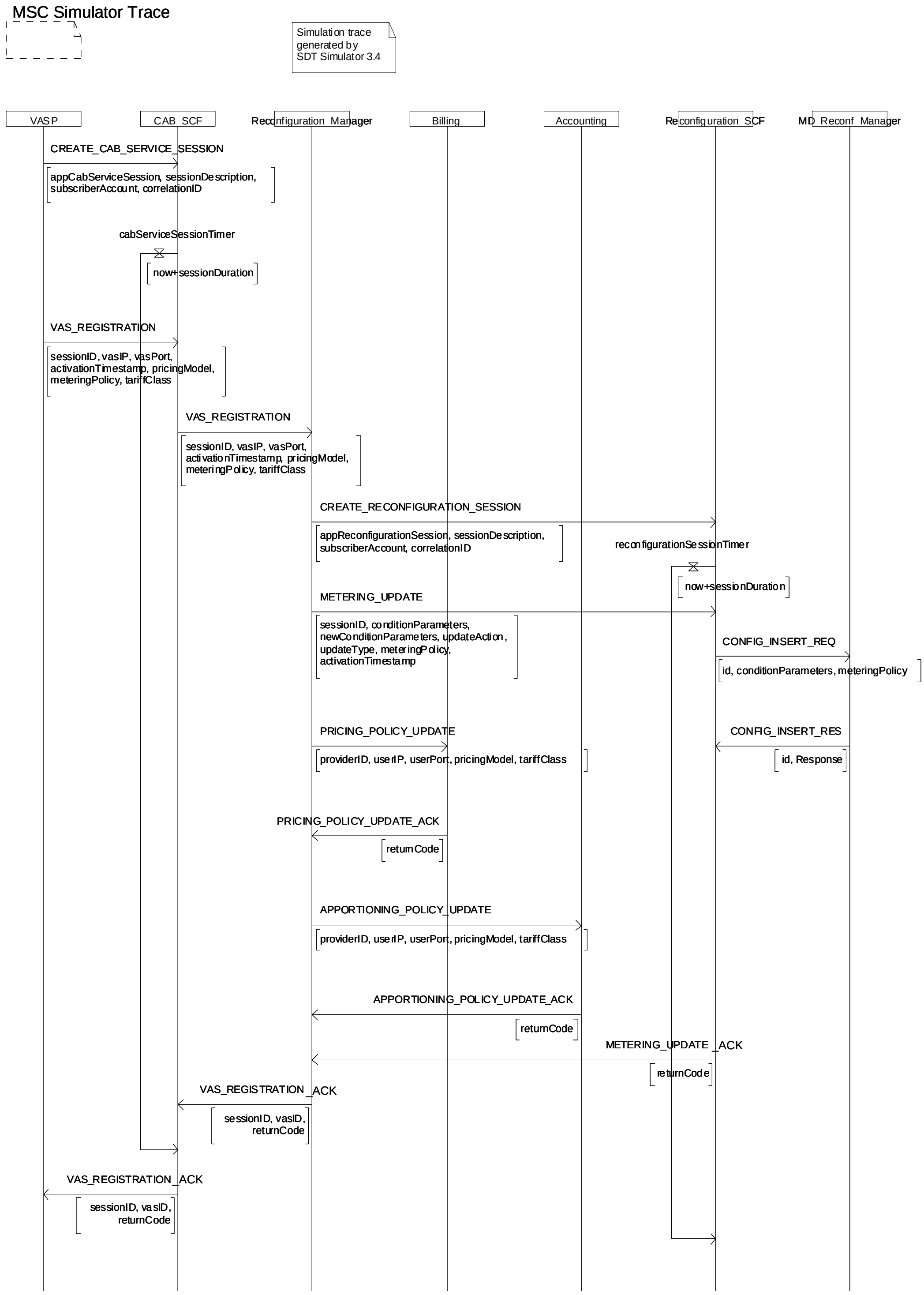

Fig. 4. The Message Sequence Chart of the VAS registration scenario

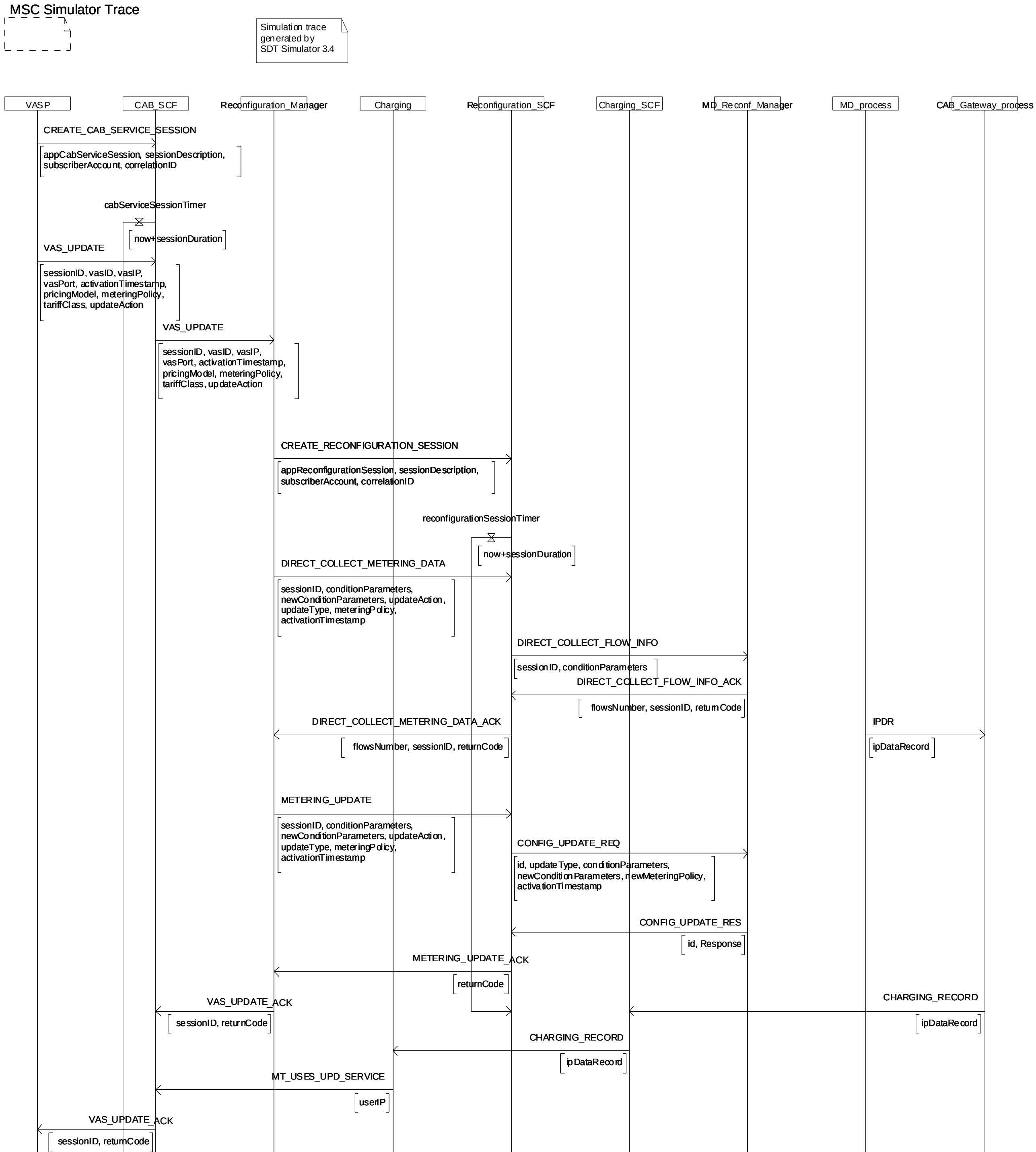

Fig. 5. The Message Sequence Chart of the VAS update scenario

The second scenario illustrated in Fig. 5 deals with the modification of the metering policy of a registered VAS during the execution of this VAS. The SPMP enables the authorised VASPs to modify the elements of their services (e.g., the VAS identity details, the metering policy, the pricing model or the tariffs) at any time. In case that these services are currently executed by a number of users, the SPMP undertakes the task, apart from reconfiguring the MDs appropriately, to inform the involved users about the change in the metering or pricing policy for the specific VAS, as well as to calculate the charges accordingly.

Similarly, to the first scenario the VAS provider establishes a session with the CAB service (CREATE_CAB_SERVICE_ SESSION) in order to update the applied metering policy for a registered VAS

(VAS_UPDATE).

Such a request triggers the Reconfiguration Manager to establish a session with the Reconfiguration SCF (CREATE_RECONFIGURATION_SESSION) in order to stimulate the MDs to close and send immediately the IPDRs concerning the specific VAS (DIRECT_ COLLECT_METERING_DATA) and to reconfigure the MDs (METERING_UPDATE) as previous. The Reconfiguration SCF triggers the MD Reconfiguration Manager (DIRECT_COLLECT_FLOW_ INFO, CONFIG_UPDATE_REQ), respectively. The MD Reconfiguration Manager not only changes the configuration of the MDs, but also imposes the immediate finalisation and forwarding of all the IPDRs that concern the specific VAS to the CAB Gateway. The COPS messages between the MD Reconfiguration Manager and MDs are not presented in Fig. 5.

The CAB Gateway processes the received charging information (IPDR) and transmits it to the Charging module of the CAB service through the Charging SCF of the extended OSA (CHARGING_RECORD). The Charging module retrieves the users that are currently executing the specific VAS after processing of the record (i.e. ipDataRecord) and provides the CAB SCF with the appropriate users information in order to be informed (MT_USES_UPD_SERVICE).

After the successful completion of the reconfiguration actions the CAB SCF informs the VASP (VAS_UPDATE_ACK) while the involved user is notified by the SPMP.

6 Conclusions

This paper presented the design of charging information management and exploitation functional entities, integrated in advanced flexible service provision middleware platform. The entities presented meet advanced requirements for intelligent charging information management, customized billing and reconfigurability control through open APIs offered by the proposed middleware platform. The platform and functional entities have been designed and verified using the Specification and Description Language (SDL) [21] and simulation results have been produced.

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