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(54) **Title**: CELLULAR NETWORK USAGE MONITORING

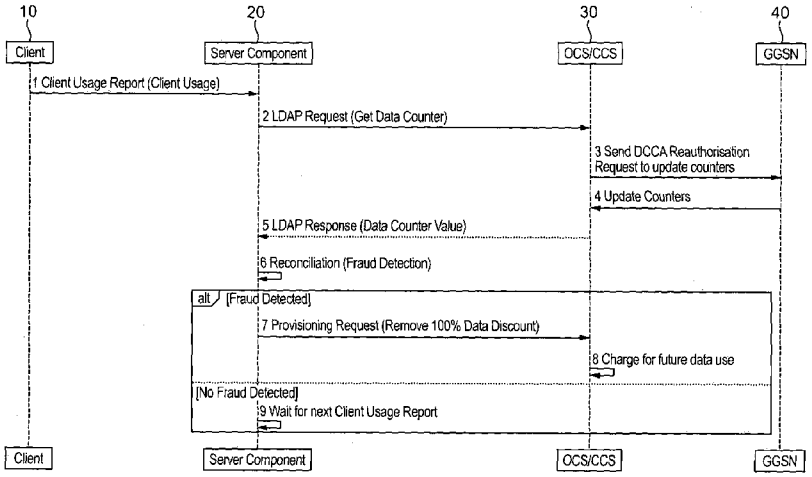

FIG. 4

(57) **Abstract**: The present invention provides a network entity in a cellular radio network for monitoring usage of data communication between a mobile subscriber and the cellular radio network. The network entity comprises : a first interface for receiving a first indication of the mobile subscriber's data communication usage from the mobile subscriber; a second interface for receiving a second indication of the mobile subscriber's data communication usage from a charging entity of the cellular radio network, the first and second indications relating to the mobile subscriber's data communication usage in the same time period; and a processor configured to compare the first and second indications in order to determine an accuracy of the first indication.

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CELLULAR NETWORK USAGE MONITORING

Field of the Invention

The invention relates to a network entity in a cellular radio network or a method for monitoring usage of data communication between a mobile subscriber and the cellular radio network.

Background to the Invention

With the ascending popularity of Smartphone devices, data communication services are of increasing importance to mobile network operators. Monitoring and management of data communications usage by individual mobile subscribers is a key issue. Data communications are typically packet-switched in nature and can be characterised by the quantity of data communicated (in the uplink, downlink or both) and by the time span of data communication, but also by more complex measurements. These complex measurements may divide the data usage according to a range of characteristics, that may include: priority level, Quality of Service (QoS), specific application or a combination of these factors. For instance, some data communications may be used for high-priority services whilst others may allow more latency. Services may also be characterised by their instantaneous data rate requirements (for example streaming applications in particular).

Such usage monitoring can be relevant for a variety of different usages, including differentiated service, research purposes for network improvements and system optimisation. It is also particularly used in charging (that is, billing) mobile subscribers. It is desirable that charging mirrors actual usage as close as possible to reflect the value of different types of data and data service. Different network entities and functionalities dependent on the network architecture have been specified by the Third Generation Partnership Project (3GPP). For example, monitoring can take place using the Gy interface defined at an Online Charging System (OCS) within an existing architecture.

Existing approaches for monitoring and management of data communications usage only use information accessible at the cellular radio

network. On the one hand, this information is reliable and robust. On the other, it is limited in scope as it cannot necessarily identify the specific services and usage at a granular level. Moreover, significant network resources are required to monitor cellular network usage effectively. An improved way to carry out this monitoring would be advantageous.

Summary of the Invention

Against this background, the present invention provides a network entity in a cellular radio network for monitoring usage of data communication between a mobile subscriber and the cellular radio network. The network entity comprises: a first interface for receiving a first indication of the mobile subscriber's data communication usage from the mobile subscriber; a second interface for receiving a second indication of the mobile subscriber's data communication usage from a charging entity of the cellular radio network, the first and second indications relating to the mobile subscriber's data communication usage in the same time period; and a processor configured to compare the first and second indications in order to determine an accuracy of the first indication.

The present invention may therefore be considered a Device-Assisted solution that uses monitoring information obtained at the mobile subscriber's device (User Equipment, UE). This may then provide additional detail that may not be readily available in the traditional network entities involved or responsible for monitoring usage and especially charging. the first indication is determined using a computer program operative at User Equipment, UE, of the mobile subscriber. The network entity may be called a server component, for instance. Either or both of first interface and second interface may be a formally defined interface between two network entities (as understood with reference to 3GPP architectures), or it may simply be a port for input, output or both. In particular, the second interface may use one or more of: a Gy interface; a Simple Object Access Protocol (SOAP) interface; and a Common Object Request Broker Architecture (CORBA) interface.

In the context of the present invention a cellular radio network can be understood not only to refer to conventional cellular radio access network architectures, such as GSM, UMTS, LTE or similar, but also to other forms of

subscriber-based radio access networks, including networks based on WiFi, WiMax and other similar types of network design.

In the area of charging, the approach is referred to as "Smart Charging." Mitigating the reliability and robustness problems inherent in such an approach may be achieved by concurrently monitoring the mobile subscriber's data communication usage within the cellular radio network, especially the core network and particularly using a charging entity. A comparison or reconciliation may be carried out to identify an accuracy for the data communication usage reported by the mobile subscriber's device. If the accuracy is below a desired level, the cellular radio network can take steps to improve the accuracy or to avoid problems stemming from the use of inaccurate information.

Preferably, the first indication is determined using a computer program operative at a UE of the mobile subscriber. In other words, the monitoring information is obtained by a client installed on the mobile terminal (that is, UE) of the mobile subscriber. The mobile subscriber may be identified by the Subscriber Identity Module (SIM) coupled to the UE. If the computer program is operative at the UE, changing the SIM that is coupled to the UE may affect the monitoring. This will be discussed below.

Advantageously, the second indication is determined by communication between the charging entity and a packet switched network entity. For example, the packet switched network entity may be a General Packet Radio Service (GPRS) Support Node (GSN), such as a Gateway GPRS Support Node (GGSN) or a Service GPRS Support Node (SGSN). Beneficially, the communication between the charging entity and a packet switched network entity may use one or more Charging Data Records (CDRs). In preferred embodiments, the packet switched network entity communicates with the charging entity to determine a data usage quota and allows the mobile subscriber an amount of data usage based on the data usage quota. In some embodiments, the charging entity and packet switched entity may be combined in one network entity. Optionally, the combined entity may be configured to comprise further functionality, such as content filtering and optimisation.

The present invention may be applicable in a variety of different cellular radio network architectures and designs, for instance network configurations based on GSM (2G), UMTS (3G) and LTE (4G). In the preferred embodiments, the charging entity comprises an Online Charging System (OCS) or Convergent Charging System (CCS). In the charging scenario, the monitoring information received from the device may be integrated with Online Charging Infrastructure using entities standardised by the Third Generation Partnership Project (3GPP) that are commonly used to support Pre-Pay customers but also Post-Pay customers in a converged charging system. For the purpose of this document a solution is described in terms of supporting Pre-Pay customers but it should be noted that this approach is equally applicable for Post-Pay customers when operators use converged charging (i.e. they use the OCS for Post-Pay)

Optionally, the first and second indications of the mobile subscriber's data communication usage comprise indications of any one or a combination of: a quantity of data; a quantity of time; and a plurality of data or time amounts, each data or time amount relating to a respective service. This may allow differentiation in terms of one or more of: charging; and Quality of Service (QoS).

Preferably, the processor is further configured to send a request for the second indication to the charging entity via the second interface in response to receipt of the first indication via the first interface. Thus, the report from the charging entity is responsive to receipt of a report from the UE.

In some embodiments, the first interface is configured to receive an indication from the mobile subscriber that the subscriber is monitoring the data communication usage. This may be used to confirm that the device-assisted monitoring and/or charging is enabled. Then, the processor may be further configured to send an instruction to the charging entity via the second interface to determine the second indication of the mobile subscriber's data communication usage by applying a 100% discount to a tariff for data communications usage. Thus, a mechanism for obtaining the indication of the mobile subscriber's data communication usage from the charging entity may use the existing data usage counters within the charging entity but

disabling the charging process, for example by applying a 100% discount to the tariff, thereby avoiding use of the charging part of the charging entity for carrying out monitoring.

The network entity advantageously further comprises: a third interface for receiving an indication from a Device Status Notification System, DSNS, that data communications usage between the mobile subscriber and the cellular radio network has been initiated. This may allow the network entity to determine that a data communications session has been initiated and therefore expect to receive a monitoring report from the device in due course. As with the first and second interfaces, the third interface may simply be a port for input, output or both, although a formally defined interface may optionally be used. Optionally, the DSNS comprises one of more of: a system for sending a push notification to the mobile subscriber; an interface to a Home Location Register, HLR; an interface to an Authentication, Authorization and Accounting, AAA, system; a Gy interface; a Gx interface; and a RADIUS interface.

The use of the DSNS may allow detection of unanticipated changes or fraud in the monitoring. For instance, the processor may further configured to begin a timer in response to receipt of the indication via the second interface. The processor may then be further configured to identify that the mobile subscriber will not supply an indication of its data usage if the timer reaches a predetermined value before the network entity has received the first indication of the mobile subscriber's data communication usage from the mobile subscriber via the first interface. Additionally or alternatively, the processor may be further configured to begin a timer in response to receipt of the first indication of the mobile subscriber's data communication usage via the first interface. Then, the processor may be further configured to identify that the mobile subscriber will not supply an indication of its data usage if the timer reaches a predetermined value before the network entity has received a further first indication of the mobile subscriber's data communication usage from the mobile subscriber via the first interface.

Identifying that the mobile subscriber will not supply an indication of its data usage may mean that the UE of the mobile subscriber is now coupled to a different SIM or that some fraudulent activity has taken place. Mitigating

such problems may be advantageous. The processor is optionally further configured to send an instruction to the charging entity via the second interface not to apply a 100% discount to a tariff for data communications usage in response to an identification that the SIM of the UE used in the mobile terminal of mobile subscriber has been changed.

In an alternative aspect, there is provided a method for monitoring usage of data communication between a mobile subscriber and a cellular radio network, comprising: receiving at a network entity an indication from a Device Status Notification System, DSNS, that data communications usage between the mobile subscriber and the cellular radio network has been initiated; starting a timer at the network entity in response to receipt of the indication from the DSNS; and identifying that the mobile subscriber will not supply an indication of its data usage if the timer reaches a predetermined value before the network entity has received the first indication of the mobile subscriber's data communication usage from the mobile subscriber via the first interface.

In yet another aspect, there is provided a method for monitoring usage of data communication between a mobile subscriber and a cellular radio network, comprising: receiving at a network entity an indication of the mobile subscriber's data communication usage from the mobile subscriber; receiving at the network entity a second indication of the mobile subscriber's data communication usage from a charging entity of the cellular radio network, the first and second indications relating to the mobile subscriber's data communication usage in the same time period; and comparing the first and second indications in order to determine an accuracy of the first indication. Optionally, the method may further comprise authorising a level of data communication between the mobile subscriber and the cellular radio network.

It will be understood that this method can optionally comprise steps corresponding with the operative features described in connection with the network entity detailed above. The invention may be further provided as a computer program, configured to carry out the method as described herein when operated on a processor or as a computer readable medium comprising such a computer program. Also, any combination of the

individual apparatus features or method features described may be implemented, even though not explicitly disclosed.

Brief Description of the Drawings

A method and system according to the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 illustrates a block diagram showing a High Level Architecture of a network arrangement in which an embodiment of the invention may be implemented;

Figure 2: shows a schematic depiction of the Leveraging of Existing Tariff Constructs and OCS/CCS Capabilities;

Figure 3: illustrates the Leveraging of Existing Tariff Constructs and OCS/CCS Capabilities when Fraud is Detected**;**

Figure 4: depicts a flow of information showing an overview of the monitoring and reconciliation process in accordance with the invention;

Figure 5: illustrates a flow of information showing an overview of the operation of a customer purchases smart charging enabled device in accordance with the invention;

Figure 6: illustrates a flow of information showing an overview of the operation of a customer purchases smart charging+ tariff enabled device in accordance with the invention;

Figure 7: illustrates a flow of information showing a SIM swap scenario; and

Figure 8: illustrates a flow of information showing a fraud detection scenario.

Detailed Description of a Preferred Embodiment

In the following description of the present invention, a number of abbreviations will be used. A selection of these abbreviations are defined as follows:

AAA: Authentication, Authorization and Accounting;

AVP: Attribute Value Pair;

CDR: Call Detail Record, contain details of the service usage;

GGSN: Gateway GPRS Support Node;

OCS: Online Charging System;

PCEF: Policy Control Enforcement Function;

PCRF: Policy and Charging Rules Function;

RNC: Radio Network Controller; and

SGSN: Serving GPRS Support Node.

In addition, certain conventional and/or useful terms will be used, the following definitions will assist the reader.

Smart Charging Device: A Device with the Smart Charging Client installed.

Non Smart Charging Device: A Device without the Smart Charging Client installed.

Tariff: A bundle of voice minutes, text messages and data.

Smart Charging: Smart Charging explores ways of creating new charging mechanisms and tariff structures to offer greater convenience and flexibility for customers.

Smart Charging+: Smart Charging + builds on the Smart Charging capabilities by leveraging a Device Client to provide the means to charge users based on their actual on-device usage and current context.

Smart Charging Tariff: A bundle of voice minutes, text messages and data where the data part is managed by the OCS/CCS.

Smart Charging+ Tariff: A bundle of voice minutes, text messages and data where the data part is managed by the Server Controller.

Services: Services are the components that the end Customer selects for purchase. Services contain information about the associated Billing Policy and Access Policies (e.g., filters, notifications, and actions).

Offer: An Offer is a collection of Services that are grouped together and presented to the end-customer for purchase.

Access Policies: Access Policies define the details of the Service including the filters for specific web site destinations and applications and the actions to take when there is a filter match.

Billing Policies: Billing Policies define the billing parameters and notifications associated with a service plan. Cost items are used for display purposes only (e.g., notifying the end-customer of cost, overage, etc.).

IC Timer: The Initial Connect Timer: the timer that the Server Controller starts when it is notified that a customer has established a data session/PDP Context. The Client is expected to contact the Server Controller before this timer expires.

UR Timer: The Usage Reporting Timer: the timer that the Server Controller starts when it receives an Initial Connect or Usage Report message from the Client. The Client is expected to report usage to the Server Controller periodically based on the reporting rules associated with the active Service(s).

Referring first to Figure 1, there is shown a block diagram showing a High Level Architecture of a network arrangement. For the purposes of illustration, the method of monitoring will be described below in connection with a Device Assisted Smart Charging solution. This interacts with the following components: the Client 10; the Server Component (SC) 20, which may incorporate a Tariff Designer; an Online Charging System (OCS) 30; a GGSN/SGSN 40; a DSNS 50; a Payment Web Service (PWS) 60; a Revenue Assurance entity; a Mediation entity; a CRM System; a CVM System; a Customer Care entity; and SMS & Other Notification Gateways. This is now used to explain the

With a Device assisted solution a Smart Charging+ Client is a secure component that provides policy enforcement and accounting for data service usage. The client retrieves policies from the Server Component and enforces these, in parallel it records data usage and sends this information back to the Server Component.

The Client also provides a user dashboard so that the user can obtain real-time feedback on their usage but also as a means for the user to select and purchase tariff/plans/offers.

It should be noted that the techniques and mechanisms to ensure the integrity and robustness of the Client are out of scope of this document.

It should be noted that for Smart Charging Tariffs that are stored and managed on the OCS the client can be a downloadable Application.

The Server Component is the main integration point with both core and IT infrastructure of the network operator and the Client.

The Client connects to the Server Component in order to download the tariff/plans/offers that are available to the end user. In addition the Client sends the usage information that it generates based on data usage on the device to the Server Component for billing purposes.

The Server Component interacts with the operators' core and IT infrastructure to notify it of user purchases, potential fraud and other service specific events.

The Server Component also interfaces with the OCS/CCS 30 in order to support both Smart Charging and Smart Charging+ capabilities. Within the architecture diagram LDAP, CORBA and XML provisioning are shown as some examples, however, this solution can leverage any available interface including but not limited to a Web Services Interface.

The Tariff Designer allows the creation and provisioning of new tariffs/plans/offers that are made available via the Client.

A GSN is a network node which supports the use of GPRS in the GSM core network. All GSNs should have a Gn interface and support the GPRS tunnelling protocol. There are two key variants of the GSN, namely Gateway and Serving GPRS Support Node.

The GGSN 40 is responsible for the interworking between the GPRS network and external packet switched networks. The GGSN converts the GPRS packets coming from the SGSN into the appropriate packet data protocol (PDP) format (e.g., IP or X.25) and sends them out on the corresponding packet data network. In the other direction, PDP addresses of incoming data packets are converted to the GSM address of the destination user. The readdressed packets are sent to the responsible SGSN. For this purpose, the GGSN 40 stores the current SGSN address of the user and his or her profile in its location register. The GGSN 40 is responsible for IP address assignment and is the default router for the connected user equipment (UE). The GGSN 40 also performs authentication and charging functions.

A Serving GPRS Support Node (SGSN) is responsible for the delivery of data packets from and to the mobile stations within its geographical

service area. Its tasks include packet routing and transfer, mobility management (attach/detach and location management), logical link management, and authentication and charging functions.

In the interest of brevity the SGSN is not shown in the architecture, yet its presence may be understood if and when appropriate.

Online charging is a process where charging information for network resource usage is collected concurrently with that resource usage in the same fashion as in offline charging. However, authorization for the network resource usage must be obtained by the network prior to the actual resource usage to occur. This authorization is granted by the Online Charging System upon request from the network.

An Online Charging System (OCS) 30 is a key enabler for pre-pay and supports real-time, service usage based charging. The Online Charging System (OCS) supports the following functions:

(i) rating (before and/or after service consumption):

- unit determination: calculation and reservation of a number of session-related non-monetary units (service units, data volume, time and events); • price determination: calculation of monetary units (price) for a given number of non-monetary units;
- tariff determination: determination of tariff information based on the subscribers contractual terms and service being requested (e.g. information for AoC);
- get/set counters applicable for rating (alternatively these counters can be here or in the subscriber account balance management function).

(ii) Subscriber account balance management:

- check account balance;
- account balance update (credit/debit);
- account balance reservation;
- get/set counters;
- get/set expiry date of the (prepaid) account (optional).

(iii) Charging transaction control:

- perform charging control on request basis for bearer and events/services;

- immediate charging and charging with reservation;
- generation of charging information/CDR per charging transaction.

(iv) Advice of charge:

- receive tariff information from external system;
- provide Advice of Charge information (tariff and/or cost).

When receiving a network resource usage request, the network assembles the relevant charging information and generates a charging event towards the OCS in real-time. The OCS then returns an appropriate resource usage authorization. The resource usage authorization may be limited in its scope (e.g. volume of data or duration), therefore the authorization may have to be renewed from time to time as long as the user's network resource usage persists.

Within 3GPP terminology the Charging Trigger Function (CTF) generates charging events based on the observation of network resource usage. The Ro protocol is a diameter protocol that allows a (logical) CTF to issue charging events to an Online Charging Function (OCF). The charging events can be immediate, event-based, or session-based.

The Device Status Notification System (DSNS) 50 pushes notifications (in real-time) to systems that need to be notified that a subscriber has established a data session. This can be used to help determine if the user has swapped their SIM from one device with a Smart Charging Application (or Smart Charging + Client) to a device that does not have the Smart Charging application (or Smart Charging + Client). This notification service can be realised in a number of different manners using a wide variety of protocols and systems. A non-definitive list of examples is provided below.

The Payment Web Service (PWS) 60 provides a globally available (and abstracted) web services interface that supports the charging of post-pay and pre-pay customers. It should be noted that this entity is not necessarily required as other interfaces (e.g. direct payment via interface with OCS or other billing\payment system) exist and can be used.

Revenue Assurance systems ensure that customers are being billed accurately and according to the terms of their contract and ensure that there is no revenue leakage from the charging and billing systems.

The Customer Relationship Management System encompasses a number of different elements and feeds the Customer Care system.

The Customer Value Management System provides support for promotional offers and other traditional CVM functions.

The SMS & Other Notification Gateways provides the ability to send SMS messages and other Push notifications (including OEM specific push services e.g. Apple Push Notification Service, Google Android Cloud to Device Messaging) to devices and applications.

There are several challenges to delivering a Device Assisted Smart Charging solution that can interwork with the existing charging and policy infrastructure as well as other OSS and BSS systems. For example a single product catalogue is desirable as it minimise fragmentation in OSS/BSS systems and architectures. However, since a Device Assisted solution can support a more innovative and diverse set of charging paradigms (we will refer to this as a Smart Charging+) some form of dual product catalogue is inevitable. Having said this it is possible to arrange that the CRM system ingest data from different systems and present a single unified view. It is therefore expected that this distributed yet federated product catalogue approach represents an ideal way to integrated a Device Assisted Smart Charging solution, however, it by no means is a pre-requisite as other integration options exist.

Other challenges relate to the fact that users are billed based on their IMSI/MSISDN (which are a bound to their SIM) and yet within a Device Assisted Smart Charging solution an embedded client is required on the device. As the user has the ability to remove their SIM the solution needs to cope with this situation. Furthermore, by placing policy enforcement and detailed byte counting functionality in this client there is a risk that malicious users can modify the client to circumvent charges. The following section covers the general approach taken to support Fraud Detection and Prevention within the Device Assisted Smart Charging solution.

Given that a Device Assisted Smart Charging solution relies on a device client for policy enforcement and accounting there is a risk that users will attempt to hack or subvert the client in order to gain access for free or at a reduced cost.

At a high level there are several ways in which a user can "attack" or subvert the system in order to gain access for free (or at a reduced cost), users can:

- Remove SIM and place in separate device which does not have a Client installed. This is an issue since the network accounts for data usage and charges users based on IMSI/MSISDN which are bound to the SIM.
- Hack the Client to prevent (or download additional software that prevents) the sending of usage reports to the Server Component
- Hack the Client and modify the usage reports it sends to the Server Component

Therefore the system desirably provides mechanisms that can reliably detect and act upon this type of fraudulent behaviour. One potential solution to this problem is to compare the detailed usage information from the Clients with network generated usage information

In addition to detecting fraudulent behaviour it must also be possible to either block fraudulent users or charge them accordingly (e.g. using conventional charging paradigms) for fraudulent use. This is particularly relevant in a pre-pay scenario as in many cases operators may not know the end user and have no way of charging them directly. Since in the case of fraud the client may be compromised it is not possible to rely on the usage information from the client. Therefore, when fraud is detected conventional volume/time based charging can be applied using the existing charging capabilities within the network (at this point the user should at least be notified that this change in charging has been applied).

With the Device Assisted Smart Charging solution it is possible to define the volume and time reporting limits for a given tariff/plan/offering at design time. Therefore the Server Component can potentially determine if the sending of usage reports are purposefully blocked (either through a modified client or by additional software) by detecting the case where the client has not connected in order to report usage information. When a data session is established the Client contacts the Server Component in order to check for newly available tariffs/plans/offers and also to check if the user has

purchased a new tariff/plan/offering via a different channel (e.g. phone call to Customer Care, in shop etc).

In order to detect these cases the Server Component needs to be notified by the network that a data session has started i.e. their online status. This approach also helps to address the case where the user takes their SIM from a Device Assisted Smart Charging enabled device and attempts to use it with a device that does not have the Client installed. There are several options available to achieve this device online status functionality including use of RADIUS, Diameter (Gx and Gy), more generally from an AAA system(s), a solution based on leveraging the HLR, etc. It should be noted that these are simply examples and it is not a definitive list. Within the architecture diagram shown in Figure 1 this functionality is referred to as a generic Device Status Notification System (DSNS) 50 which can be realised using any of the aforementioned mechanisms or indeed via any other mechanism that can provide the same information. Depending on the capability of DSNS 50 used and specifically whether it can reliably identify the new device and its Smart Charging+ capabilities (or lack thereof) the Device Assisted Smart Charging solution may need to start an Initial Connect (IC) Timer on notification that a Smart Charging user has established a data session as a means to determine if the user has swapped their SIM. Since the Device Assisted Smart Charging Client is designed to contact the Server Component as soon as possible, upon a data connection becoming available. By using an appropriate value for the IC Timer the Server Component can determine in the case where the IC Timer expires AND it has not be contacted by the Client that the user has swapped their SIM into another device that does not have the Device Assisted Smart Charging Client installed.

Within a pre-pay environment the Online Charging System (OCS) is a key enabler that provides real-time, service usage based charging. Furthermore, in a network adopting a Convergent Charging solution the OCS evolves into a Convergent Charging System (CCS) and provides real-time charging support for post-pay users.

In a convergent approach the Voice, Messaging and Data components of an overall tariff/plan may be managed by the OCS/CCS or alternatively the

OCS/CCS may provide real-time charging (and notification) capabilities for the Data component only for post-pay customers.

The Device Assisted Smart Charging solution presented here assumes that the OCS/CCS manages at least the data parts of both post-pay and pre-pay user's tariff.

Given this it is possible, using existing Tariff constructs, for the OCS to store and manage Smart Charging Tariffs based on Volume and Time. Furthermore, if the network supports Application detection and has the capability to charge based on URL or more generally on services then these types of tariffs can also be managed by the OCS.

As previously mentioned the Device Assisted Smart Charging system should reconcile usage reports from the Client with usage information from the network for the purposes of fraud detection. Furthermore, in a commercial deployment an operator may wish to have the flexibility to group different sized voice and messaging bundles as well as offering a more a la carte/self-service Smart Charging capability for data.

Referring to Figures 2 and 3, there are shown a schematic depiction of the Leveraging of Existing Tariff Constructs and OCS/CCS capabilities which illustrates this concept. Figure 3 shows the situation when fraud is detected, as will be discussed below. The Device Assisted Smart Charging system leverages existing tariff constructs defined and managed within the OCS. However, in order to prevent double charging (charging by the OCS and via the Device Assisted Smart Charging Solution), a 100% discount is applied to the data element/part of the tariff. The use of this concept is advantageous in so much that it allows the Device Assisted Smart Charging solution to leverage the existing data counters within the OCS for reconciliation purposes and also leverage the real-time provisioning capabilities of the OCS to remove the 100% discount when fraud is detected. Once the 100% discount is removed the user will be charged according to the principles already defined within the data element/part of the tariff.

It should be noted that it is also possible to use other tariffing constructs such as Bolt-ons (with zero rated data), recurring promotional constructs that provide a free data allowance and other such tariffing

constructs that can be dynamically provisioned/de-provisioned. The key requirements are:

a. the OCS maintains data counters that the SC can leverage for fraud detection purposes

b. the OCS supports real-time or dynamic provisioning or de-provisioning of any such tariffing construct as a means to dynamically switch users between a Device Assisted Smart Charging solution and conventional charging solutions.

It may also be desirable for the SC to maintain (or obtain via the appropriate interfaces) specific details/parameters of the tariff construct used to cater for such factors as tariff roll over (for constructs based on recurring promotion).

The following paragraphs show how the various entities interact with each other in the following scenarios: Reconciliation Process (overview); Customer Purchases Smart Charging Enabled Device; Customer Purchases Smart Charging+ Tariff; SIM Swap; and Fraud Detected.

It should be noted that for the purpose of these flows:

a. it is assumed that the data part of the tariffs defined within the OCS/CSS specify a daily data charge (with an associated fair usage limit/cap), but any other charging regime can be employed at the operator's discretion;

b. a 100% discount is used to effectively zero rate a user's data usage but other existing charging constructs could also be used (e.g. a recurring promotional offer, or a zero rated data bolt-on) as long as the OCS maintains a data counter that the SC can use for fraud reconciliation purposes; and

c. interactions are shown to illustrate the generic principles and that the other alternative flows are possible.

Referring now to Figure 4, there is illustrated a flow of information showing an overview of the reconciliation process in accordance with the invention. As can be seen, the client 10 provides a usage report to the SC 20. This prompts the SC 20 to request an indication of the usage from the OCS/CCS 30. In turn, the OCS/CCS 30 then interfaces with the GGSN 40 to update the data counters at the OCS/CCS 30 and then provides the usage indication to the SC 20. The SC 20 compares the indication received from

the Client 10 with that received from the OCS/CCS 30 and this reconciliation can establish if a fraud is detected. If a fraud is detected, the SC 20 may contact the OCS/CCS 30 to remove any discounts applied. Otherwise, the SC 20 simply awaits the next usage report from the client 10.

Referring next to Figure 5, there is illustrated a flow of information showing an overview of the operation of a customer purchases smart charging enabled device. This also shows how a data connection is established, including the sending of a registration request from the client 10 to the SC 20, to allow the client to initialise the monitoring and charging process.

Referring then to Figure 6, there is illustrated a flow of information showing an overview of the operation of a customer purchases smart charging+ tariff enabled device. After activation of a PDP context, the client 10 sends a connect request to the SC 20 to allow a charging plan to be set up.

Referring next to Figure 7, there is illustrated a flow of information showing a SIM swap scenario. It shows how the Device Status Notification System component can be used to help determine if the user has swapped their SIM from one device with a Smart Charging Application (or Smart Charging + Client) to a device that does not have the Smart Charging application (or Smart Charging + Client).

Referring finally to Figure 8, there is illustrated a flow of information showing a fraud detection scenario. Here the behaviour before and after fraud detection is contrasted. Note that a preferred method for actually detecting fraud in such systems is to compare detailed usage information from the Client 10 with network generated usage information from the OCS/CCS 30, as shown in Figure 4.

Although a specific embodiment of the invention has now been described, the skilled person will understand that various variations and modifications may be made without departing from the scope of the invention. For example, the specific network entities used for the procedures described herein may be changed according to the architecture of the network and the interfaces, protocols or both used within that architecture.

Although a software client has been used for providing monitoring reports from the mobile subscriber, it will be recognised that this can be achieved in different ways, for example using firmware or hardware or a combination or hardware and firmware, hardware and software or both. An OCS can be used to implement various time-based, volume-based or both tariffs with discounts, promotions etc. The use of a device client adds user context, allowing operators to build complex and even personalised monitoring and tariffs that meet customer demand, for example catering for a user who only wants to use a specific service or application.

CLAIMS

1. A network entity in a cellular radio network for monitoring usage of data communication between a mobile subscriber and the cellular radio network, the network entity comprising:

a first interface for receiving a first indication of the mobile subscriber's data communication usage from the mobile subscriber;

a second interface for receiving a second indication of the mobile subscriber's data communication usage from a charging entity of the cellular radio network, the first and second indications relating to the mobile subscriber's data communication usage in the same time period; and

a processor configured to compare the first and second indications in order to determine an accuracy of the first indication.

2. The network entity of claim 1, wherein the first indication is determined using a computer program operative at a User Equipment, UE, of the mobile subscriber.

3. The network entity of claim 1 or claim 2, wherein the second indication is determined by communication between the charging entity and a packet switched network entity.

4. The network entity of any preceding claim, wherein the charging entity comprises an Online Charging System, OCS, or Convergent Charging System, CCS.

5. The network entity of any preceding claim, wherein the first and second indications of the mobile subscriber's data communication usage comprises indications of any one or a combination of: a quantity of data; a quantity of time; and a plurality of data or time amounts, each data or time amount relating to a respective service.

6. The network entity of any preceding claim, wherein the processor is further configured to send a request for the second indication to the charging

entity via the second interface in response to receipt of the first indication via the first interface.

7. The network entity of any preceding claim, wherein the first interface is configured to receive an indication from the mobile subscriber that the subscriber is monitoring the data communication usage and wherein the processor is further configured to send an instruction to the charging entity via the second interface to determine the second indication of the mobile subscriber's data communication usage by applying a 100% discount to a tariff for data communications usage.

8. The network entity of any preceding claim, further comprising:

a third interface for receiving an indication from a Device Status Notification System, DSNS, that data communications usage between the mobile subscriber and the cellular radio network has been initiated.

9. The network entity of claim 8, wherein the DSNS comprises one of more of: a system for sending a push notification to the mobile subscriber; an interface to a Home Location Register, HLR; an interface to an Authentication, Authorization and Accounting, AAA, system; a Gy interface; a Gx interface; and a RADIUS interface.

10. The network entity of claim 8 or claim 9, wherein the processor is further configured to begin a timer in response to receipt of the indication via the second interface and to identify that the mobile subscriber will not supply an indication of its data usage if the timer reaches a predetermined value before the network entity has received the first indication of the mobile subscriber's data communication usage from the mobile subscriber via the first interface.

11. The network entity of any preceding claim, wherein the processor is further configured to begin a timer in response to receipt of the first indication of the mobile subscriber's data communication usage via the first interface and to identify that the mobile subscriber will not supply a further indication of

its data usage if the timer reaches a predetermined value before the network entity has received a further first indication of the mobile subscriber's data communication usage from the mobile subscriber via the first interface.

12. The network entity of claim 10 or claim 11, when dependent upon claim 7, wherein the processor is further configured to send an instruction to the charging entity via the second interface not to apply a 100% discount to a tariff for data communications usage in response to an identification that the SIM of the UE used in the mobile terminal of mobile subscriber has been changed.

13. A method for monitoring usage of data communication between a mobile subscriber and a cellular radio network, comprising:

receiving at a network entity an indication of the mobile subscriber's data communication usage from the mobile subscriber;

receiving at the network entity a second indication of the mobile subscriber's data communication usage from a charging entity of the cellular radio network, the first and second indications relating to the mobile subscriber's data communication usage in the same time period; and

comparing the first and second indications in order to determine an accuracy of the first indication.

14. A computer program, configured to carry out the method of claim 13 when operated on a processor.

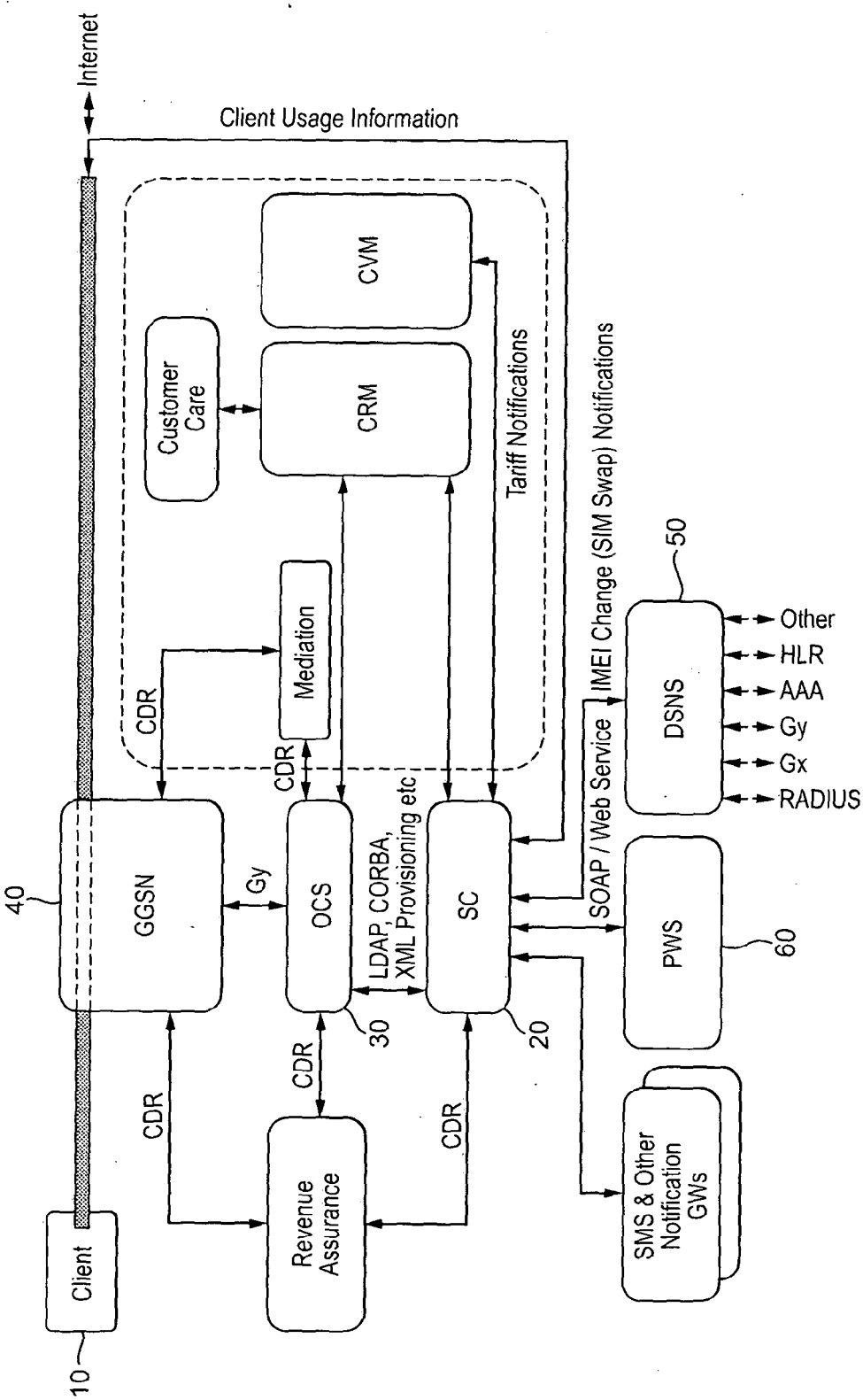
Internet
Client Usage Information
CVM
Customer Care
CRM
Tariff Notifications
Mediation
CDR
CDR
IMEI Change (SIM Swap) Notifications
50
DSNS
Other
HLR
AAA
Gy
Gx
RADIUS
40
GGSN
Gy
OCS
LDAP, CORBA, XML Provisioning etc
SC
SOAP / Web Service
PWS
60
30
20
CDR
CDR
CDR
Revenue Assurance
SMS & Other Notification GWs
Client
10

FIG. 1

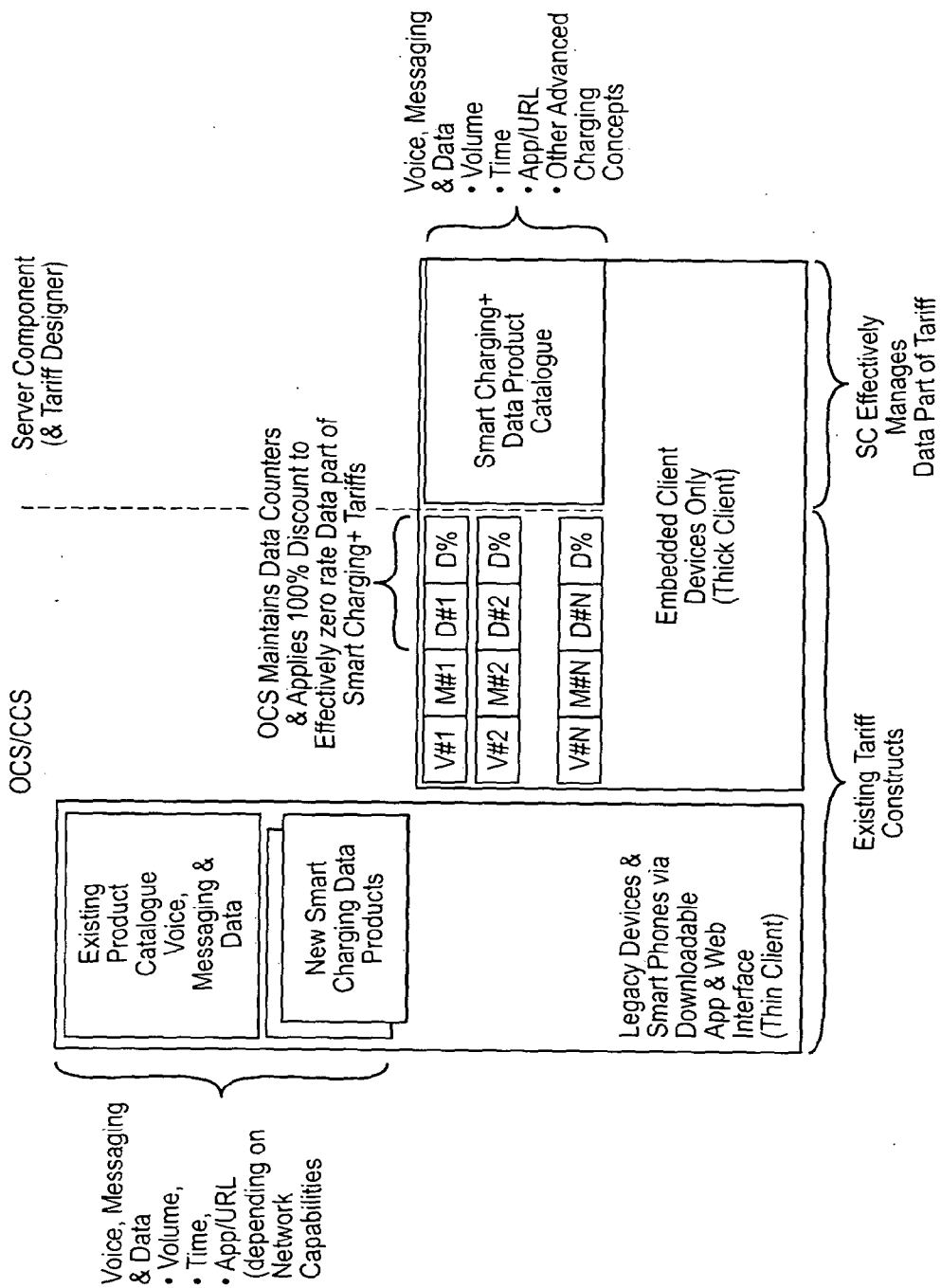
OCS/CCS
Server Component
(& Tariff Designer)
OCS Maintains Data Counters
& Applies 100% Discount to
Effectively zero rate Data part of
Smart Charging+ Tariffs
Voice, Messaging
& Data
• Volume
• Time
• App/URL
• Other Advanced
Charging
Concepts
Existing
Product
Catalogue
Voice,
Messaging &
Data
New Smart
Charging Data
Products
V#1
M#1
D#1
D%
V#2
M#2
D#2
D%
V#N
M#N
D#N
D%
Smart Charging+
Data Product
Catalogue
Embedded Client
Devices Only
(Thick Client)
Legacy Devices &
Smart Phones via
Downloadable
App & Web
Interface
(Thin Client)
Voice, Messaging
& Data
• Volume,
• Time,
• App/URL
(depending on
Network
Capabilities
Existing Tariff
Constructs
SC Effectively
Manages
Data Part of Tariff

FIG. 2

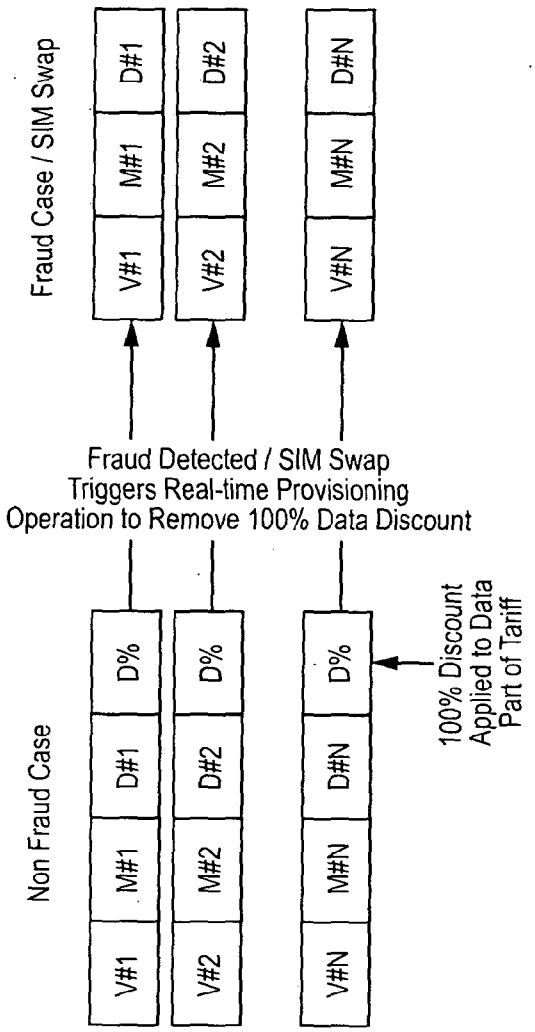
Fraud Case / SIM Swap
V#1
M#1
D#1
V#2
M#2
D#2
V#N
M#N
D#N
Fraud Detected / SIM Swap
Triggers Real-time Provisioning
Operation to Remove 100% Data Discount
Non Fraud Case
V#1
M#1
D#1
D%
V#2
M#2
D#2
D%
V#N
M#N
D#N
D%
100% Discount
Applied to Data
Part of Tariff

FIG. 3

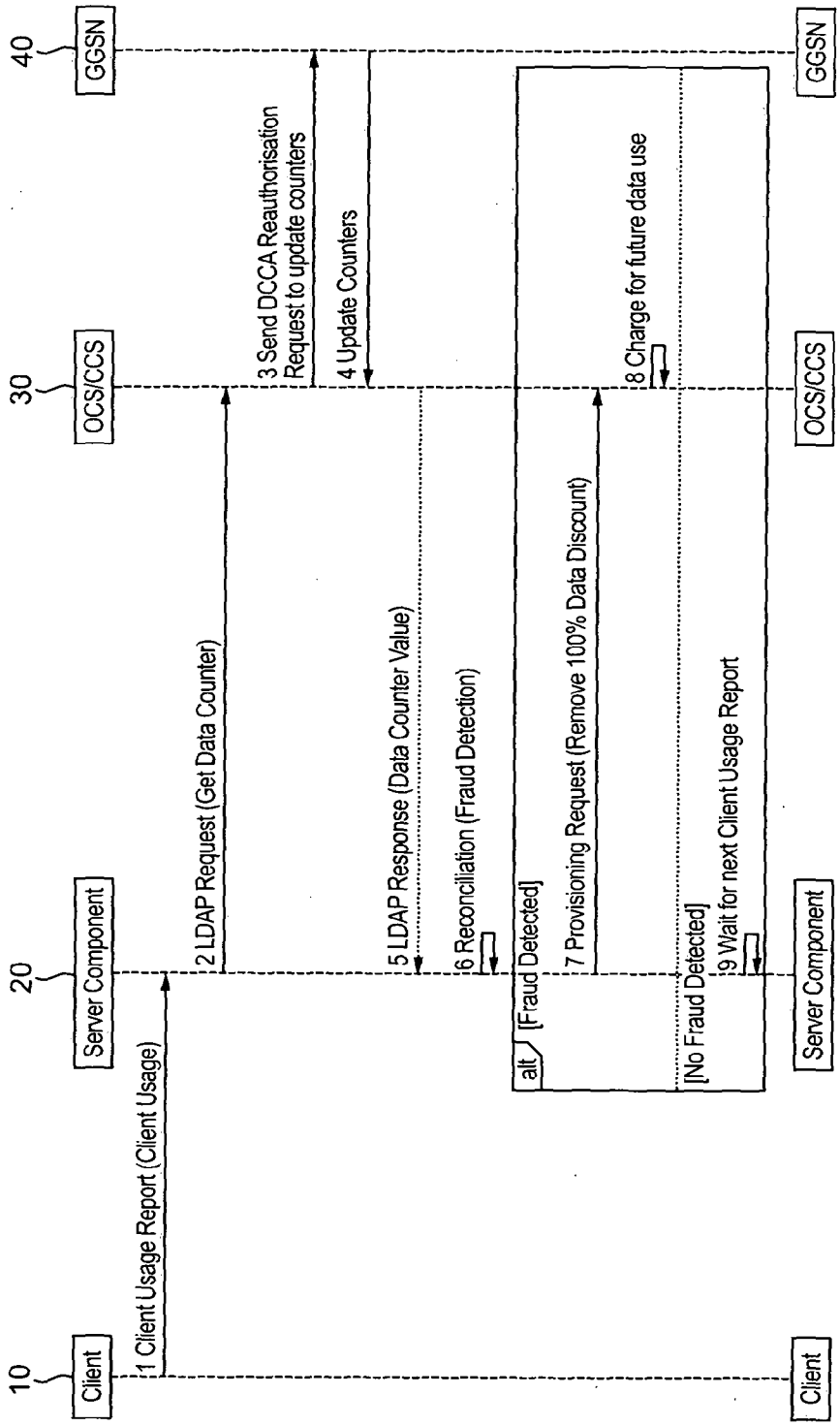
10
Client
20
Server Component
30
OCS/CCS
40
GGSN
1 Client Usage Report (Client Usage)
2 LDAP Request (Get Data Counter)
3 Send DCCA Reauthorisation Request to update counters
4 Update Counters
5 LDAP Response (Data Counter Value)
6 Reconciliation (Fraud Detection)
alt
[Fraud Detected]
7 Provisioning Request (Remove 100% Data Discount)
8 Charge for future data use
[No Fraud Detected]
9 Wait for next Client Usage Report

FIG. 4

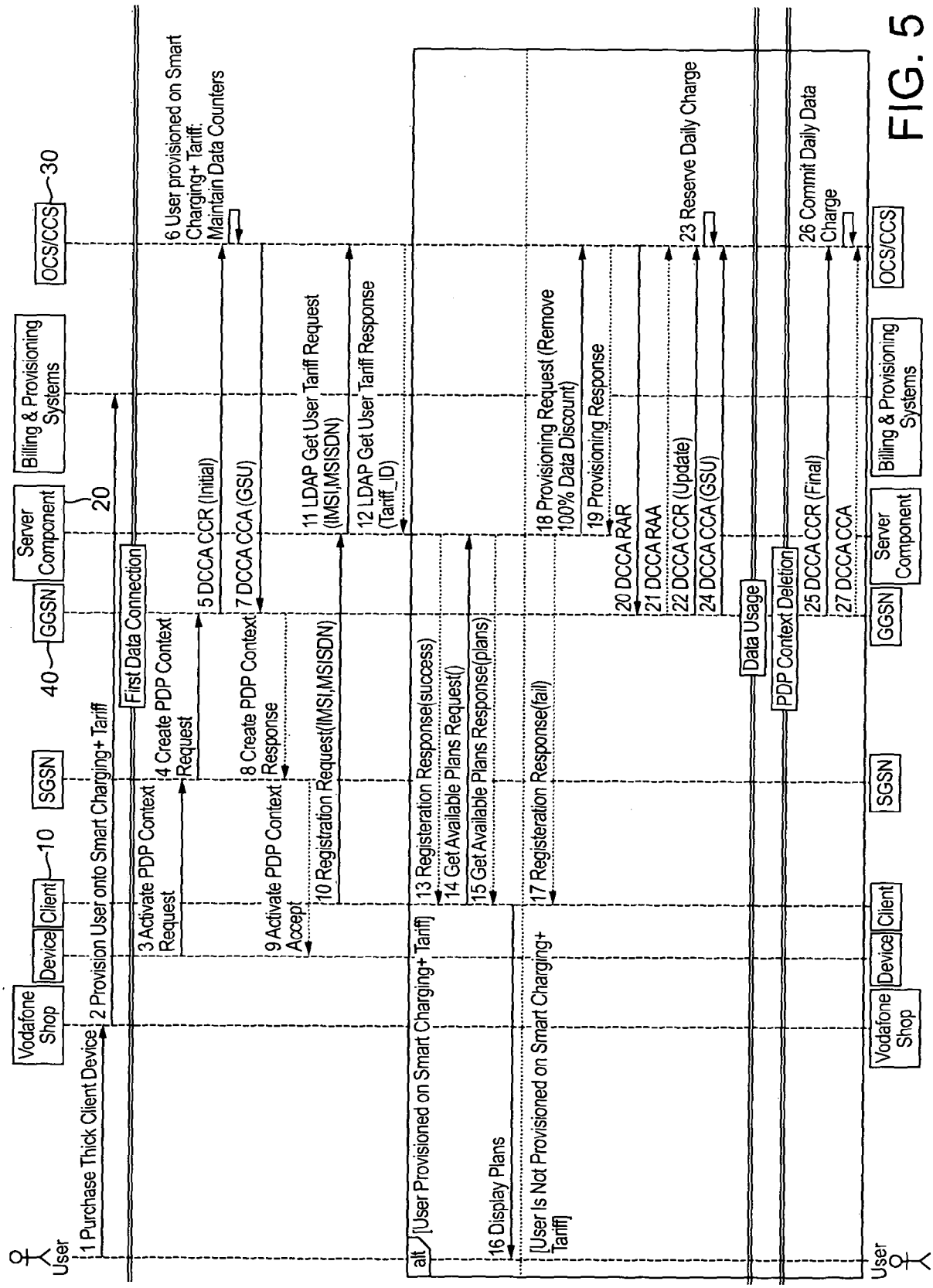
User
Vodafone Shop
Device
Client
10
SGSN
40
GGSN
Server Component
20
Billing & Provisioning Systems
OCS/CCS
30
1 Purchase Thick Client Device
2 Provision User onto Smart Charging+ Tariff
First Data Connection
3 Activate PDP Context Request
4 Create PDP Context Request
5 DCCA CCR (Initial)
6 User provisioned on Smart Charging+ Tariff: Maintain Data Counters
7 DCCA CCA (GSU)
8 Create PDP Context Response
9 Activate PDP Context Accept
10 Registration Request(IMSI,MSISDN)
11 LDAP Get User Tariff Request (IMSI,MSISDN)
12 LDAP Get User Tariff Response (Tariff_ID)
alt
[User Provisioned on Smart Charging+ Tariff]
13 Registeration Response(success)
14 Get Available Plans Request()
15 Get Available Plans Response(plans)
16 Display Plans
[User Is Not Provisioned on Smart Charging+ Tariff]
17 Registeration Response(fail)
18 Provisioning Request (Remove 100% Data Discount)
19 Provisioning Response
20 DCCA RAR
21 DCCA RAA
22 DCCA CCR (Update)
23 Reserve Daily Charge
24 DCCA CCA (GSU)
Data Usage
PDP Context Deletion
25 DCCA CCR (Final)
26 Commit Daily Data Charge
27 DCCA CCA

FIG. 5

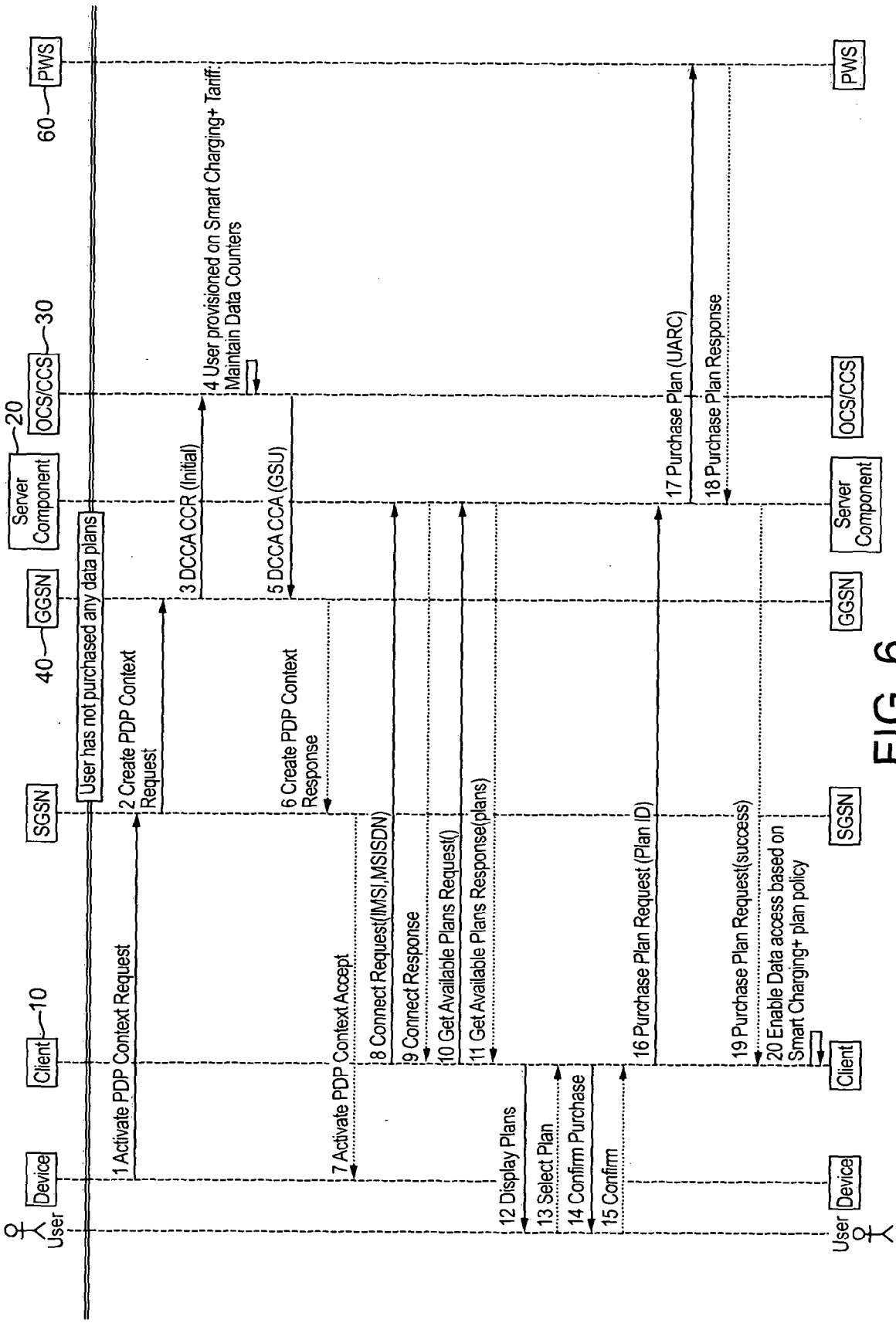
User
Device
Client
10
SGSN
40
GGSN
Server Component
20
OCS/CCS
30
60
PWS
User has not purchased any data plans
1 Activate PDP Context Request
2 Create PDP Context Request
3 DCCA CCR (Initial)
4 User provisioned on Smart Charging+ Tariff: Maintain Data Counters
5 DCCA CCA (GSU)
6 Create PDP Context Response
7 Activate PDP Context Accept
8 Connect Request(IMSI,MSISDN)
9 Connect Response
10 Get Available Plans Request()
11 Get Available Plans Response(plans)
12 Display Plans
13 Select Plan
14 Confirm Purchase
15 Confirm
16 Purchase Plan Request (Plan ID)
17 Purchase Plan (UARC)
18 Purchase Plan Response
19 Purchase Plan Request(success)
20 Enable Data access based on Smart Charging+ plan policy

FIG. 6

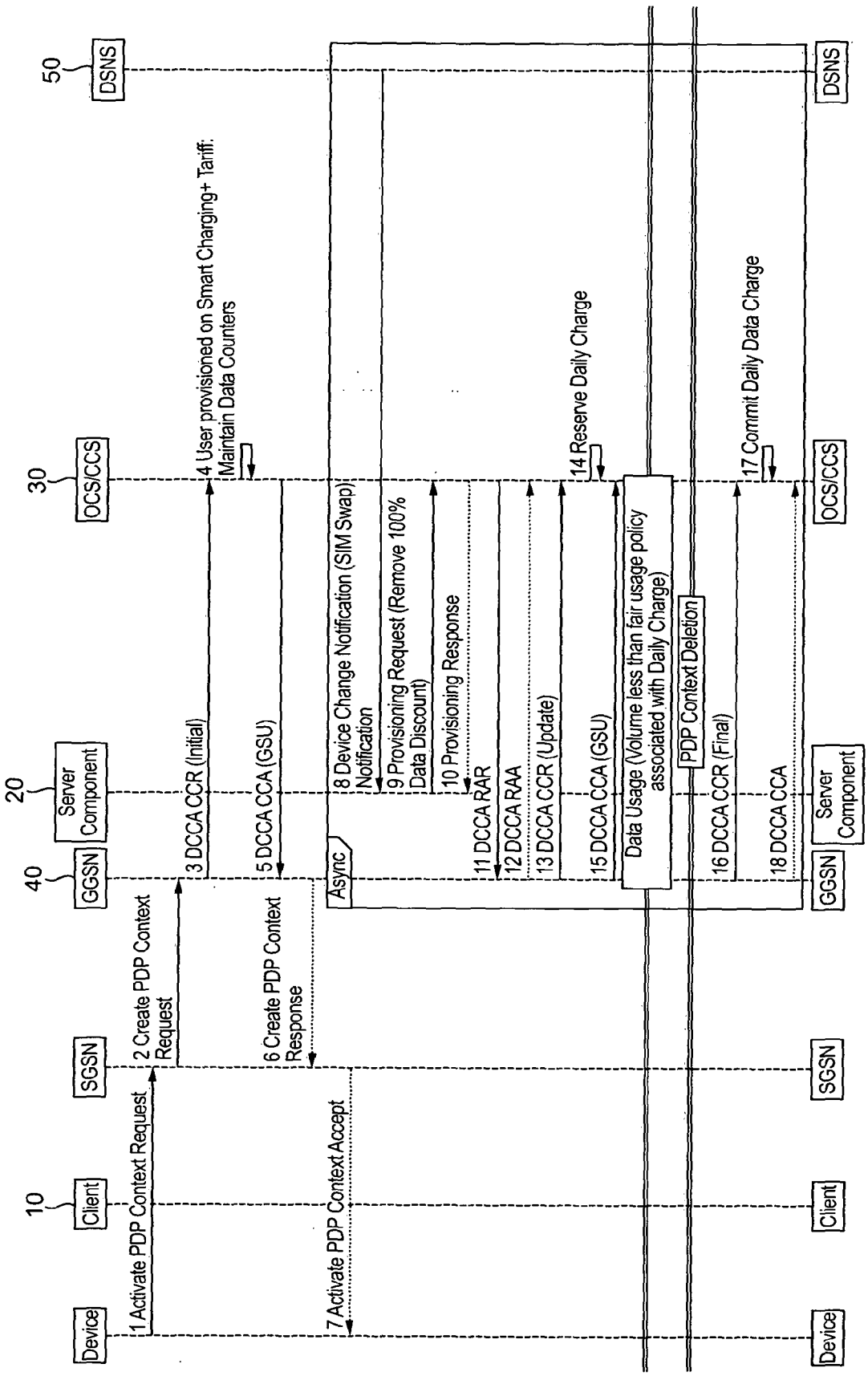
Device
Client
10
SGSN
GGSN
40
Server Component
20
OCS/CCS
30
DSNS
50
1 Activate PDP Context Request
2 Create PDP Context Request
3 DCCA CCR (Initial)
4 User provisioned on Smart Charging+ Tariff: Maintain Data Counters
5 DCCA CCA (GSU)
6 Create PDP Context Response
7 Activate PDP Context Accept
Async
8 Device Change Notification (SIM Swap) Notification
9 Provisioning Request (Remove 100% Data Discount)
10 Provisioning Response
11 DCCA RAR
12 DCCA RAA
13 DCCA CCR (Update)
14 Reserve Daily Charge
15 DCCA CCA (GSU)
Data Usage (Volume less than fair usage policy associated with Daily Charge)
PDP Context Deletion
16 DCCA CCR (Final)
17 Commit Daily Data Charge
18 DCCA CCA

FIG. 7

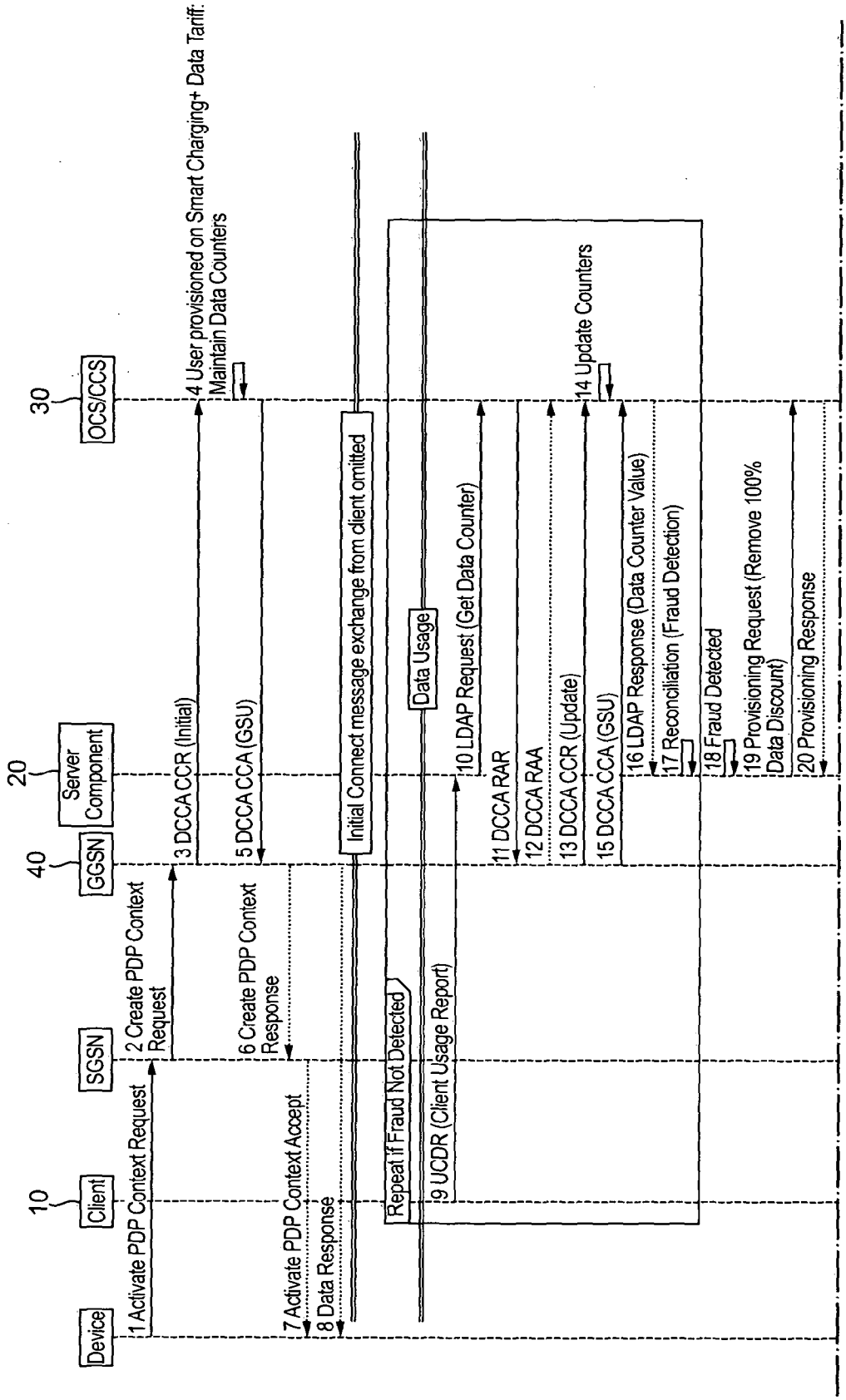
Device
10
Client
SGSN
40
GGSN
20
Server Component
30
OCS/CCS
1 Activate PDP Context Request
2 Create PDP Context Request
3 DCCA CCR (Initial)
4 User provisioned on Smart Charging+ Data Tariff: Maintain Data Counters
5 DCCA CCA (GSU)
6 Create PDP Context Response
7 Activate PDP Context Accept
8 Data Response
Initial Connect message exchange from client omitted
Repeat if Fraud Not Detected
Data Usage
9 UCDR (Client Usage Report)
10 LDAP Request (Get Data Counter)
11 DCCA RAR
12 DCCA RAA
13 DCCA CCR (Update)
14 Update Counters
15 DCCA CCA (GSU)
16 LDAP Response (Data Counter Value)
17 Reconciliation (Fraud Detection)
18 Fraud Detected
19 Provisioning Request (Remove 100% Data Discount)
20 Provisioning Response

FIG. 8

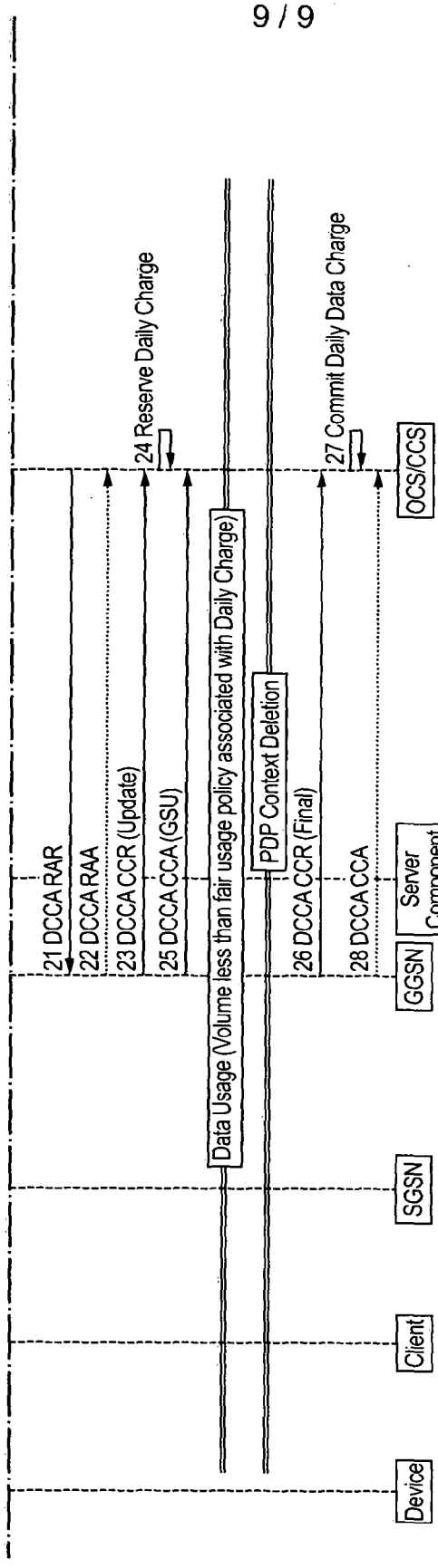
Device
Client
SGSN
GGSN
Server Component
OCS/CCS
21 DCCA RAR
22 DCCA RAA
23 DCCA CCR (Update)
24 Reserve Daily Charge
25 DCCA CCA (GSU)
Data Usage (Volume less than fair usage policy associated with Daily Charge)
PDP Context Deletion
26 DCCA CCR (Final)
27 Commit Daily Data Charge
28 DCCA CCA

FIG. 8 CONT'D

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2013/050356

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L12/14 H04W88/18 H04M15/00 H04W4/24 H04W12/12
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04L H04W H04M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, COMPENDEX, INSPEC, IBM-TDB, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/314145 A1 (RALEIGH GREGORY G [US] ET AL) 22 December 2011 (2011-12-22) abstract paragraph [0109] - paragraph [0147] paragraph [0235] - paragraph [0248] figures 1,2,4C -----	1-14
X	US 2005/177515 A1 (KALAVADE ASAWAREE [US] ET AL) 11 August 2005 (2005-08-11) abstract paragraph [0069] paragraph [0140] paragraph [0180] paragraph [0279] -----	1-14

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 July 2013	30/07/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Aura Marcos, F

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2013/050356

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2011314145 A1	22-12-2011	US 2011314145 A1	22-12-2011
		WO 2012102827 A2	02-08-2012
US 2005177515 A1	11-08-2005	CA 2555767 A1	25-08-2005
		EP 1782576 A2	09-05-2007
		US 2005177515 A1	11-08-2005
		WO 2005076884 A2	25-08-2005