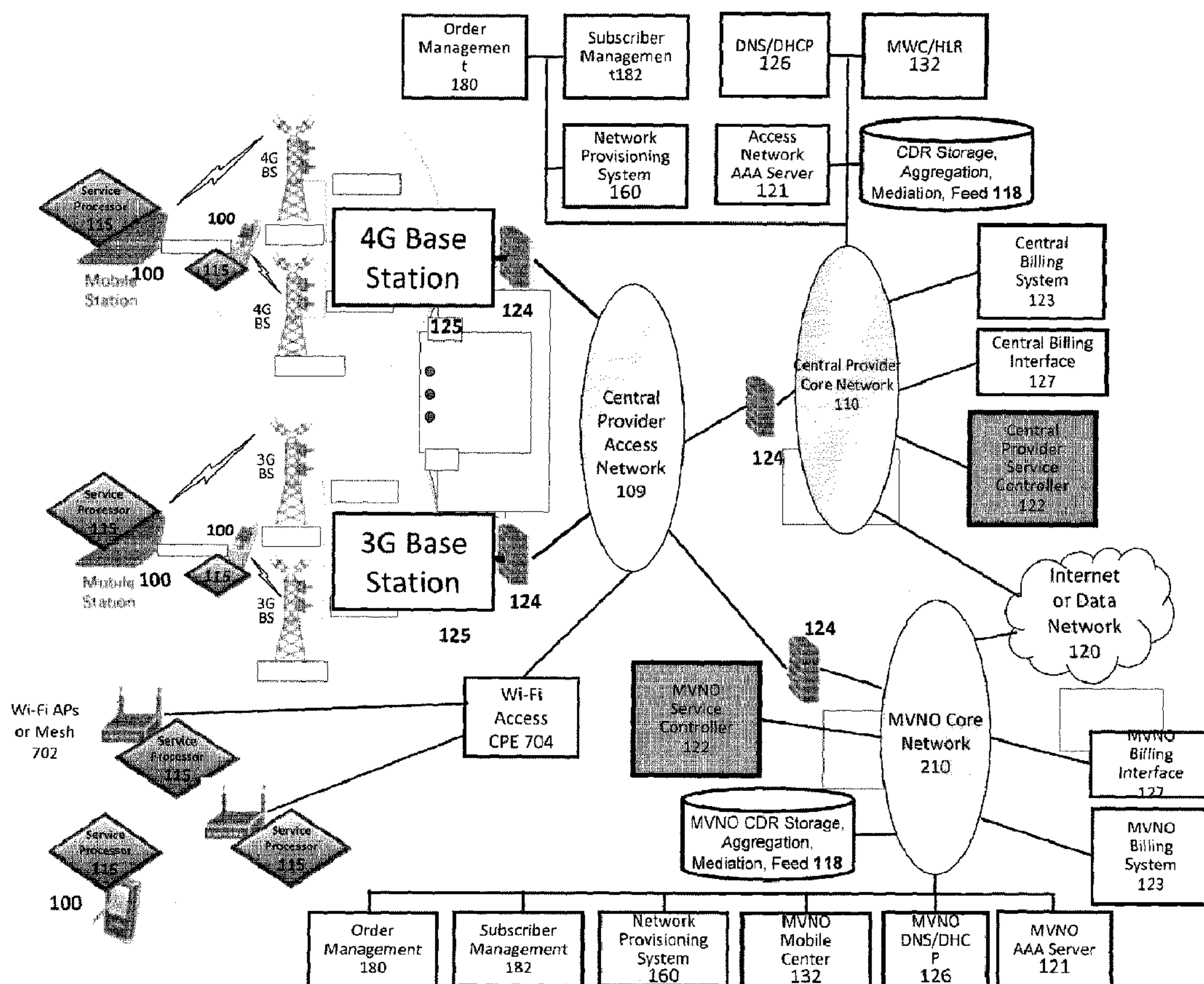




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(57) **Abrégé/Abstract:**

A uniform wireless network service selection information exchange interface system is provided to facilitate a consistent user experience across multiple wireless networks that may have different service plan activation or service plan purchase processes.



(57) Abrégé(suite)/Abstract(continued):

Network detection of service usage anomalies based on device-based data usage reports is provided to enable the network to determine whether an end-user device is likely operating in accordance with the established policy, or whether the end-user device may be operating fraudulently.

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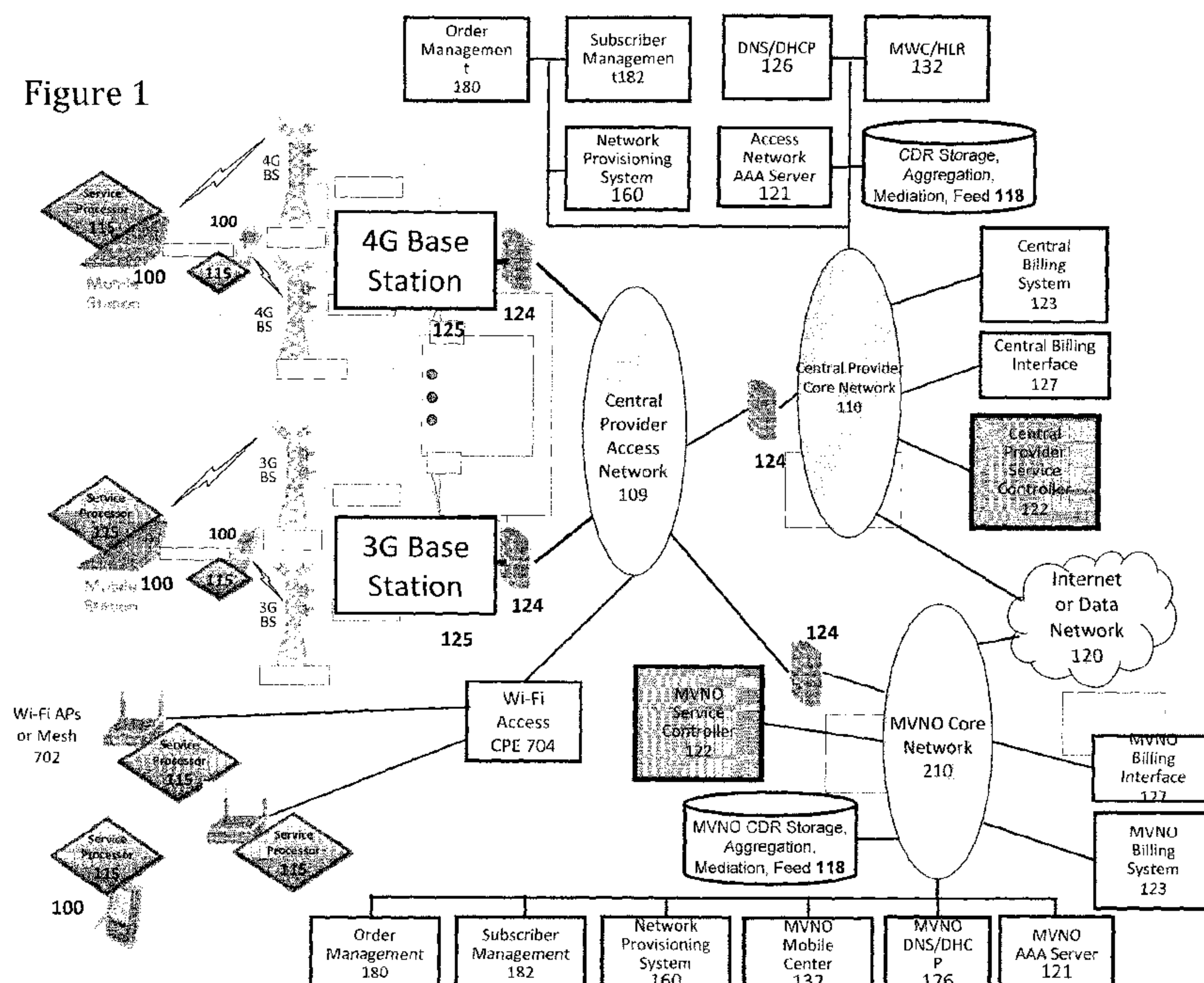
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[Continued on next page]

(54) Title: WIRELESS NETWORK SERVICE INTERFACES

Figure 1



(57) Abstract: A uniform wireless network service selection information exchange interface system is provided to facilitate a consistent user experience across multiple wireless networks that may have different service plan activation or service plan purchase processes. Network detection of service usage anomalies based on device-based data usage reports is provided to enable the network to determine whether an end-user device is likely operating in accordance with the established policy, or whether the end-user device may be operating fraudulently.

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WIRELESS NETWORK SERVICE INTERFACES

BACKGROUND

[0001] With the advent of mass market digital communications and content distribution, many access networks such as wireless networks, cable networks and DSL (Digital Subscriber Line) networks are pressed for user capacity, with, for example, EVDO (Evolution-Data Optimized), HSPA (High Speed Packet Access), LTE (Long Term Evolution), WiMax (Worldwide Interoperability for Microwave Access), and Wi-Fi (Wireless Fidelity) wireless networks increasingly becoming user capacity constrained. Although wireless network capacity will increase with new higher capacity wireless radio access technologies, such as MIMO (Multiple-Input Multiple-Output), and with more frequency spectrum being deployed in the future, these capacity gains are likely to be less than what is required to meet growing digital networking demand.

[0002] Similarly, although wire line access networks, such as cable and DSL, can have higher average capacity per user, wire line user service consumption habits are trending toward very high bandwidth applications that can quickly consume the available capacity and degrade overall network service experience. Because some components of service provider costs go up with increasing bandwidth, this trend will also negatively impact service provider profits.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] Various embodiments are disclosed in the following detailed description and the accompanying drawings.

[0004] **Figure 1** illustrates a wireless network architecture for providing device assisted CDR creation, aggregation, mediation and billing in accordance with some embodiments.

[0005] **Figure 2** illustrates another wireless network architecture for providing device assisted CDR creation, aggregation, mediation and billing in accordance with some embodiments.

[0006] **Figure 3** illustrates another wireless network architecture for providing device assisted CDR creation, aggregation, mediation and billing in accordance with some embodiments.

[0007] **Figure 4** illustrates provisioning of a wireless network for providing device assisted CDR creation, aggregation, mediation and billing in accordance with some embodiments.

[0008] **Figure 5** illustrates a network architecture for providing device assisted CDRs in accordance with some embodiments.

[0009] **Figure 6** illustrates another network architecture for providing device assisted CDRs in accordance with some embodiments.

[0010] **Figure 7** illustrates another network architecture for providing device assisted CDRs in accordance with some embodiments.

[0011] **Figure 8** illustrates another network architecture for providing device assisted CDRs in accordance with some embodiments.

[0012] **Figure 9** is a functional diagram illustrating a device based service processor and a service controller in accordance with some embodiments.

[0013] **Figure 10** provides a table summarizing various service processor functional elements in accordance with some embodiments.

[0014] **Figure 11** provides a table summarizing various service controller functional elements in accordance with some embodiments.

[0015] **Figure 12** illustrates a device stack providing various service usage measurement from various points in the networking stack for a service monitor agent, a billing agent, and an access control integrity agent to assist in verifying the service usage measures and billing reports in accordance with some embodiments.

[0016] **Figure 13** illustrates an embodiment similar to Figure 12 in which some of the service processor is implemented on the modem and some of the service processor is implemented on the device application processor in accordance with some embodiments.

[0017] **Figure 14** illustrates various embodiments of intermediate networking devices that include a service processor for the purpose of verifiable service usage measurement, reporting, and billing reports in accordance with some embodiments.

[0018] **Figure 15** illustrates a wireless network architecture for providing device assisted CDR creation, aggregation, mediation and billing including a proxy server in accordance with some embodiments.

[0019] **Figure 16** illustrates example service controller interfaces in accordance with some embodiments.

DETAILED DESCRIPTION

[0020] The invention can be implemented in numerous ways, including as a process; an apparatus; a system; a composition of matter; a computer program product embodied on a computer readable storage medium; and/or a processor, such as a processor configured to execute instructions stored on and/or provided by a memory coupled to the processor. In this specification, these implementations, or any other form that the invention may take, may be referred to as techniques. In general, the order of the steps of disclosed processes may be altered within the scope of the invention. Unless stated otherwise, a component such as a processor or a memory described as being configured to perform a task may be implemented as a general component that is temporarily configured to perform the task at a given time or a specific component that is manufactured to perform the task. As used herein, the term 'processor' refers to one or more devices, circuits, and/or processing cores configured to process data, such as computer program instructions.

[0021] A detailed description of one or more embodiments of the invention is provided below along with accompanying figures that illustrate the principles of the invention. The invention is described in connection with such embodiments, but the invention is not limited to any embodiment. The scope of the invention is limited only by the claims and the invention encompasses numerous alternatives, modifications and equivalents. Numerous specific details are set forth in the following description in order to provide a thorough understanding of the invention. These details are provided for the purpose of example and the invention may be practiced according to the claims without some or all of these specific details. For the purpose of clarity, technical material that is known in the technical fields related to the invention has not been described in detail so that the invention is not unnecessarily obscured.

[0022] There are many new types of digital devices where it is becoming desirable, for example, to connect these devices to wireless networks including wireless wide area networks (WWAN, such as 3G and 4G) and/or wireless local area (WLAN) networks. These devices include, for example, consumer electronics devices, business user devices, and machine to machine devices that benefit from flexible wide area data connections and the Internet. Example devices include netbooks, notebooks, mobile Internet devices, personal navigation (e.g., GPS enabled) devices, music and multimedia players, eReaders, industrial telemetry, automotive emergency response and diagnostics, 2-way home and industrial power metering

and control, vending machines, parking meters, and many other devices. For example, it is highly advantageous to offer service usage and service billing plans for such devices that are more optimal for each type of device and each type of desired user experience. To accomplish this, more sophisticated service usage measuring and service usage billing systems are needed as compared to the conventional network based techniques in existence today. By providing more flexibility in service measurement and billing, more advantageous and cost effective service plans can be created for, for example, the new WWAN connected devices cited above for all three markets (e.g., consumer, business and machine to machine) that still maintain the necessary profit margins for the WWAN carriers to be successful with these various service businesses.

[0023] Accordingly, various embodiments disclosed herein provide for a new and flexible augmentation or replacement for existing carrier network service usage measurement, service usage accounting, and service usage billing systems and techniques.

[0024] A charging data record (CDR) is a term that as used herein defines a formatted measure of device service usage information, typically generated by one or more network functions that supervise, monitor, and/or control network access for the device. CDRs typically form the basis for recording device network service usage, and often form the basis for billing for such usage. Various embodiments are provided herein for device assisted CDR creation, mediation, and billing. There are many limitations to the capabilities of service usage recording, aggregation and/or billing when CDRs are generated exclusively by network based functions or equipment. Accordingly, by either augmenting network based service usage measures with device based service usage measures, or by replacing network based service usage measures with device based service usage measures, it is possible to create a CDR generation, aggregation, mediation and/or billing solution that has superior or more desirable capabilities/features. While in theory, many of the service usage measures that can be evaluated on a device can also be evaluated in the network data path using various network equipment technologies including but not limited to deep packet inspection (DPI), there are many examples where measuring service usage at the device is either more desirable or more practical, or in some cases it is the only way to obtain the desired measure. Such examples include but are not limited to the following:

- Application layer service usage measures (e.g., traffic usage categorized by application or by combinations of application, destination, and/or content type);
- Usage measures that do not involve user traffic but instead involve network overhead traffic (e.g., basic connection maintenance traffic, signaling traffic, network logon/AAA/authentication/monitoring traffic, service software update traffic);
- Usage that is associated with services that are charged to another entity other than the end user (e.g., basic network connection service offer traffic, traffic associated with providing network access to or downloading service marketing information, traffic associated with advertiser sponsored services, traffic associated with content provider sponsored services, 911 service traffic);
- Usage measures involving encrypted traffic (e.g., traffic that is run over encrypted networking protocols or between secure end points);
- Implementing service usage measure collection and/or service usage billing across multiple networks that may have different and in some cases incompatible, inaccessible (to the CDR system of record) or incomplete service usage measurement capabilities;
- Service usage measurement and/or service usage billing capabilities that are not supported by the present network gateways, routers, MWC/HLRs, AAA, CDR aggregation, CDR mediation, billing and/or provisioning systems;
- New service usage measures and/or new service usage billing capabilities that are desirable to implement in a manner that does not require major changes or upgrades to the existing network gateways, routers, MWC/HLRs, AAA, CDR aggregation, CDR mediation, billing and/or provisioning systems;
- New service usage measures and/or new service usage billing capabilities that are desirable to implement in a manner that allows for rapid definition and implementation of new service measures and/or billing plans;
- New service usage measures and/or new service usage billing capabilities that are desirable to implement in a manner that may be implemented in a manner that enables multiple device group definitions in which each device group gets a customized programmable definition for service usage collection, accounting and/or billing;
- Multi device billing;
- Multi user billing;
- Intermediate device billing with single user and multi user with and without multi device;

- Content downloads from a specific source to a specific application with the content being of a specific type or even identified down to a particular content ID; and/or
- Various other single event transactions used for billing purposes.

For these and other reasons, it is desirable to provide a system/process that utilizes device assisted service usage measures that provides either an enhancement of existing network based service usage CDR system capabilities and techniques and/or a replacement for network based CDR system capabilities and techniques.

[0025] In some embodiments, techniques, such as a system and/or process, that utilize device assisted service usage measures include one or more of the following: (1) receiving a service usage measure from a device in communication with a wireless network, (2) verifying or protecting the validity of the service usage measure, (3) generating a CDR based on the service usage measure (e.g., device assisted CDR), (4) aggregating CDRs, and (5) mediating the CDR with network CDRs. In some embodiments, the techniques also include providing a design and provisioning of devices/network equipment to recognize the CDRs. In some embodiments, the techniques also include provisioning to recognize that the device belongs to a Device Assisted Services (DAS) device group and that corresponding CDRs should be accepted and mediated. In some embodiments, the device assisted CDRs are also generated using formats, network communications protocols, network device authentication and/or provisioning to allow device assisted CDRs into the network CDR system, encryption, and/or signatures as required by the network (e.g., to comply with network generated CDR requirements or based on any other network and/or service provider requirements and/or standards).

[0026] In some embodiments, mediation rules include multi device, multi user, single user devices, and/or intermediate networking devices that can be single user or multi user, as described herein.

[0027] In some embodiments, a device assisted CDR generator collects device based service usage measures that are used as the basis for, or as an enhancement (e.g., as a supplement or in addition) to, one or more (e.g., network generated) CDRs that provide one or more networking functions with properly formatted service usage reports that the network function(s) accepts as being transmitted from an authorized source, read, and utilized for helping to determine the service usage of a device or group of devices. In some embodiments,

the network functions that the device assisted CDR generator shares CDRs with typically include one or more of the following: service usage/CDR aggregation and/or mediation servers, gateways, routers, communication nodes, Mobile Wireless Centers (MWCs, including HLRs), databases, AAA systems, billing interfaces, and billing systems. For example, the process of CDR creation in the CDR generator typically includes either using one or more device based measures of service usage, or one or more device based measures of service usage in combination with one or more network based measures of service usage, possibly processing one or more of such service usage measures according to a set of CDR creation, CDR aggregation, and/or CDR mediation rules to arrive at a final device usage measure that is, for example, then formatted with the proper syntax, framed, possibly encrypted and/or signed, and encapsulated in a communication protocol or packet suitable for sharing with network functions. In some embodiments, the CDR generator resides in the device. In some embodiments, the CDR generator resides in a network server function that receives the device assisted service usage measures, along with possibly network based usage measures, and then creates a CDR (e.g., in the service controller 122).

[0028] In some embodiments, the device assisted CDR generator can reside in the service processor (e.g., service processor 115), for example, in the service usage history or billing server functions. In some embodiments, the device assisted CDR generator resides in the device itself, for example, within the service processor functions, such as the billing agent or the service monitor agent.

[0029] There are several factors that are considered in the various embodiments in order to create a useful, reliable, and secure device assisted CDR system, including, for example, but not limited to:

- Identification of each device based service usage measure with one or more usage transaction codes;
- Verification of the device based usage measure(s);
- Secure communication of the device based usage measures to the network;
- Efficient (e.g., low bandwidth) communication of the device based service usage measure;
- Coordination/comparison/aggregation of the device based service usage measure with network based service usage measure(s);

- Formatting the device based service usage measure into a CDR that can be properly communicated to the network functions and/or equipment that process service usage information;
- Causing the network based functions and/or equipment used for CDR collection, aggregation, mediation and/or billing to recognize, authorize, and accept communications and CDRs from the device assisted CDR generator, reading and properly implementing the correct network session context for the CDR so that the CDR is properly associated with the correct device /user/session;
- Implementing the CDR aggregation rules that determine how to collect and aggregate the device assisted CDRs as they are reported through the network CDR system hierarchy;
- Implementing the mediation rules that determine how the various device based service usage transaction code measures are combined and mediated with the other device based service usage transaction code measures to result in consistent service usage information for each of the transaction code categories maintained in the network;
- Implementing the mediation rules that determine how the device assisted CDRs are combined and mediated with network based CDRs to result in consistent service usage information for each of the transaction code categories maintained in the network;
- Implementing mediation rules to reconcile the variances between network based CDR usage measures and device assisted CDR usage measures;
- Classification of one or more device groups, with each group having the capability to uniquely define the service usage collection, accounting, and/or billing rules;
- Collecting CDRs generated on networks other than the home network so that service usage may be measured, accounted for, and/or billed for across multiple networks;
- Multi device billing;
- Multi user billing; and/or
- Intermediate device billing with single user and multi user with and without multi device.

[0030] In some embodiments, verification of the relative accuracy of the device assisted service usage measure is provided. Given that, for example, the service usage measure is often being generated on an end user device or a device that is readily physically accessed by the general public or other non-secure personnel from a network management viewpoint, in

some embodiments, the device agents used in one or more of the service processor 115 agents are protected from hacking, spoofing, and/or other misuse. Various techniques are provided herein for protecting the integrity of the agents used for generating the device assisted service usage measures.

[0031] In some embodiments, the service usage measures are verified by network based cross checks using various techniques. For example, network based cross checks can provide valuable verification techniques, because, for example, it is generally not possible or at least very difficult to defeat well designed network based cross checks using various techniques, such as those described herein, even if, for example, the measures used to protect the device agents are defeated or if no device protection measures are employed. In some embodiments, network based cross checks used to verify the device assisted service usage measures include comparing network based service usage measures (e.g. CDRs generated by service usage measurement apparatus in the network equipment, such as the BTS/BSCs 125, RAN Gateways 410, Transport Gateways 420, Mobile Wireless Center/HLRs 132, AAA 121, Service Usage History/CDR Aggregation, Mediation, Feed 118, or other network equipment), sending secure query/response command sequences to the service processor 115 agent(s) involved in device assisted CDR service usage measurement or CDR creation, sending test service usage event sequences to the device and verifying that the device properly reported the service usage, and using various other techniques, such as those described herein with respect to various embodiments.

[0032] In some embodiments, one or more of the following actions are taken if the device based service usage measure is found to be in error or inaccurate: bill the user for usage overage or an out of policy device, suspend the device, quarantine the device, SPAN the device, and/or report the device to a network administration function or person.

[0033] In some embodiments, the CDR syntax used to format the device assisted service usage information into a CDR and/or network communication protocols for transmitting CDRs are determined by industry standards (e.g., various versions of 3GPP TS 32.215 format and 3GPP2 TSG-X X.S0011 or TIA-835 format). In some embodiments, for a given network implementation the network designers will specify modifications of the standard syntax, formats and/or network communication/transmission protocols. In some embodiments, for a given network implementation the network designers will specify syntax,

formats, and/or network communication/transmission protocols that are entirely different than the standards.

[0034] In some embodiments, within the syntax and formatting for the CDR the device assisted service usage is typically categorized by a transaction code. For example, the transaction code can be similar or identical to the codes in use by network equipment used to generate CDRs, or given that the device is capable of generating a much richer set of service usage measures, the transaction codes can be a superset of the codes used by network equipment used to generate CDRs (e.g., examples of the usage activities that can be labeled as transaction codes that are more readily supported by device assisted CDR systems as compared to purely network based CDR systems are provided herein).

[0035] In some embodiments, the device sends an identifier for a usage activity tag, an intermediate server determines how to aggregate into CDR transaction codes and which CDR transaction code to use.

[0036] In some embodiments, the device service processor 115 compartmentalizes usage by pre-assigned device activity transaction codes (e.g., these can be sub-transactions within the main account, transactions within a given bill-by-account transaction or sub-transactions within a bill-by-account transaction). The device implements bill-by-account rules to send different usage reports for each bill-by-account function. In some embodiments, the service controller 122 programs the device to instruct it on how to compartmentalize these bill-by-account service usage activities so that they can be mapped to a transaction code.

[0037] In some embodiments, the device reports less compartmentalized service usage information and the service controller 122 does the mapping of service usage activities to CDR transaction codes, including in some cases bill-by-account codes.

[0038] In some embodiments, the CDR sent to 118 or other network equipment, for example, can include various types of transaction codes including but not limited to a raw device usage CDR, a bill-by-account (e.g., a sub-activity transaction code) CDR, a billing offset CDR, and/or a billing credit CDR. For example, the decision logic (also referred to as business rules or CDR aggregation and mediation rules) that determines how these various types of CDR transaction codes are to be aggregated and mediated by the core network and the

billing system can be located in the network equipment (e.g., a network element, such as service usage 118), in the service controller 122, and/or in the billing system 123.

[0039] In some embodiments, the device assisted CDR generator uses the device assisted service usage measures to generate a CDR that includes service usage information, service usage transaction code(s), and, in some embodiments, network information context. In some embodiments, the service usage information, transaction code, and/or network information context is formatted into communication framing, syntax, encryption/signature, security and/or networking protocols that are compatible with the formatting used by conventional networking equipment to generate CDRs. For example, this allows networking equipment used for CDR collection, recording, aggregation, mediation, and/or conversion to billing records to properly accept, read, and interpret the CDRs that are generated with the assistance of device based service usage measurement. In some embodiments, the device assisted service measures are provided to an intermediate network server referred to as a service controller (e.g., service controller 122). In some embodiments, the service controller uses a CDR feed aggregator for a wireless network to collect device generated usage information for one or more devices on the wireless network; and provides the device generated usage information in a syntax (e.g., charging data record (CDR)), and a communication protocol (e.g., 3GPP or 3GPP2, or other communication protocol(s)) that can be used by the wireless network to augment or replace network generated usage information for the one or more devices on the wireless network.

[0040] In some embodiments, mediation rules include multi device, multi user, single user devices, intermediate networking devices that can be single user or multi user. For example, the device assisted CDRs can be formatted by the device assisted CDR generator to include a transaction code for one user account, even though the CDRs originate from multiple devices that all belong to the same user. This is an example for a multi-user device assisted CDR billing solution. In another example for a multi-user device assisted CDR billing solution, device assisted CDRs from multiple devices and multiple users can all be billed to the same account (e.g., a family plan or a corporate account), but the bill-by-account CDR transaction records can be maintained through the billing system so that sub-account visibility is provided so that the person or entity responsible for the main account can obtain visibility about which users and/or devices are creating most of the service usage billing. For example, this type of multi-user, multi-device device assisted CDR billing solution can also be used to

track types of service usage and/or bill for types of service usage that are either impossible or at least very difficult to account and/or bill for with purely network based CDR systems. In some embodiments, bill-by-account CDR transaction records can be used to provide sponsored transaction services, account for network chatter, provide service selection interfaces, and other services for multi-user or multi-device service plans.

[0041] In addition to conventional single user devices (e.g., cell phones, smart phones, netbooks/notebooks, mobile internet devices, personal navigation devices, music players, electronic eReaders, and other single user devices) device assisted service usage measurement and CDRs are also useful for other types of network capable devices and/or networking devices, such as intermediate networking devices (e.g., 3G/4G WWAN to WLAN bridges/routers/gateways, femto cells, DOCSIS modems, DSL modems, remote access/backup routers, and other intermediate network devices). For example, in such devices, particularly with a secure manner to verify that the device assisted service usage measures are relatively accurate and/or the device service processor 115 software is not compromised or hacked, many new service provider service delivery and billing models can be supported and implemented using the techniques described herein. For example, in a WiFi to WWAN bridge or router device multiple user devices can be supported with the same intermediate networking device in a manner that is consistent and compatible with the central provider's CDR aggregation and/or billing system by sending device assisted CDRs as described herein that have a service usage and/or billing code referenced to the end user and/or the particular intermediate device.

[0042] In some embodiments, the device assisted CDRs generated for the intermediate networking device are associated with a particular end user in which there can be several or many end users using the intermediate networking device for networking access, and in some embodiments, with each end user being required to enter a unique log-in to the intermediate networking device. For example, in this way, all devices that connect using WiFi to the intermediate networking device to get WWAN access generate CDRs can either get billed to a particular end user who is responsible for the master account for that device, or the CDRs can get billed in a secure manner, with verified relative usage measurement accuracy to multiple end users from the same intermediate networking device. In another example, an end user can have one account that allows access to a number of intermediate networking devices, and each intermediate networking device can generate consistent device assisted CDRs with transaction

codes for that end user regardless of which intermediate networking device the end user logs in on.

[0043] In some embodiments, some of the services provided by the intermediate networking device are billed to a specific end user device assisted CDR transaction code, while other bill-by-account services are billed to other transaction code accounts, such as sponsored partner transaction service accounts, network chatter accounts, sponsored advertiser accounts, and/or service sign up accounts. For example, in this manner, various embodiments are provided in which intermediate networking devices (e.g., a WWAN to WiFi router/bridge) can be sold to one user but can service and be used to bill other users (e.g., and this can be covered in the first purchasing user's service terms perhaps in exchange for a discount), or such intermediate networking devices can be located wherever access is desired without concern that the device will be hacked into so that services can be acquired without charge.

[0044] In some embodiments, various types of service usage transactions are billed for on the intermediate networking device, to any of one or more users, in which the information required to bill for such services is not available to the central provider or MVNO network equipment, just as is the case with, for example, conventional single user devices. In view of the various embodiments and techniques described herein, those skilled in the art will appreciate that similar service models are equally applicable not just to WWAN to WiFi intermediate networking devices, but also to the Femto Cell, remote access router, DOCSIS, DSL and other intermediate WWAN to WiFi networking devices.

[0045] **Figure 1** illustrates a wireless network architecture for providing device assisted CDR creation, aggregation, mediation and billing in accordance with some embodiments. As shown, Figure 1 includes a 4G/3G/2G wireless network operated by, for example, a central provider. As shown, various wireless devices 100 are in communication with base stations 125 for wireless network communication with the wireless network, and other devices 100 are in communication with Wi-Fi Access Points (APs) or Mesh 702 for wireless communication to Wi-Fi Access CPE 704 in communication with central provider access network 109. In some embodiments, each of the wireless devices 100 includes a service processor 115 (as shown), and each service processor connects through a secure control plane link to a service controller 122. In some embodiments, the network based service usage information (e.g., CDRs) is obtained from one or more network elements. As shown, an MVNO core network 210 also

includes a CDR storage, aggregation, mediation, feed 118, a MVNO billing interface 127, and a MVNO billing system 123 (and other network elements as shown in Figure 1).

[0046] As shown in Figure 1, a CDR storage, aggregation, mediation, feed 118 (e.g., service usage 118, including a billing aggregation data store and rules engine) is a functional descriptor for, in some embodiments, a device/network level service usage information collection, aggregation, mediation, and reporting function located in one or more of the networking equipment components attached to one or more of the sub-networks shown in Figure 1 (e.g., central provider access network 109 and/or central provider core network 110), which is in communication with the service controller 122, and a central billing interface 127. As shown in Figure 1, service usage 118 is shown as a function in communication with the central provider core network 110. In some embodiments, the CDR storage, aggregation, mediation, feed 118 function is located elsewhere in the network or partially located in elsewhere or integrated with as part of other network elements. In some embodiments, CDR storage, aggregation, mediation, feed 118 functionality is located or partially located in the AAA server 121 and/or the mobile wireless center/Home Location Register (HLR) 132 (as shown, in communication with a DNS/DHCP server 126). In some embodiments, service usage 118 functionality is located or partially located in the base station, base station controller and/or base station aggregator, collectively referred to as base station 125 in Figure 1. In some embodiments, CDR storage, aggregation, mediation, feed 118 functionality is located or partially located in a networking component in the central provider access network 109, a networking component in the core network 110, the central billing system 123, the central billing interface 127, and/or in another network component or function. This discussion on the possible locations for the network based and device based service usage information collection, aggregation, mediation, and reporting function (e.g., CDR storage, aggregation, mediation, feed 118) can be easily generalized as described herein and as shown in the other figures described herein by one of ordinary skill in the art. Also as shown in Figure 1, the service controller 122 is in communication with the central billing interface 123 (also sometimes referred to as the external billing management interface or billing communication interface) 127, which is in communication with the central billing system 123. As shown, an order management 180 and subscriber management 182 are also in communication with the central provider core network 110 for facilitating order and subscriber management of services for the devices 100 in accordance with some embodiments.

[0047] In some embodiments, the CDR storage, aggregation, mediation, feed 118 (and/or other network elements or combinations of network elements) provides a device/network level service usage information collection, aggregation, mediation, and reporting function. In some embodiments, the CDR storage, aggregation, mediation, feed 118 (and/or other network elements or combinations of network elements) collects device generated usage information for one or more devices on the wireless network (e.g., devices 100); and provides the device generated usage information in a syntax and a communication protocol that can be used by the wireless network to augment or replace network generated usage information for the one or more devices on the wireless network. In some embodiments, the syntax is a charging data record (CDR), and the communication protocol is selected from one or more of the following: 3GPP, 3GPP2, or other communication protocols. In some embodiments, the CDR storage, aggregation, mediation, feed 118 (and/or other network elements or combinations of network elements) includes a service usage data store (e.g., a billing aggregator) and a rules engine for aggregating the collected device generated usage information. In some embodiments, the syntax is a charging data record (CDR), and the network device is a CDR feed aggregator, and the CDR storage, aggregation, mediation, feed 118 (and/or other network elements or combinations of network elements) also aggregates CDRs for the one or more devices on the wireless network; applies a set of rules to the aggregated CDRs using a rules engine (e.g., bill by account, transactional billing, and/or any other billing or other rules for service usage information collection, aggregation, mediation, and reporting), and communicates a new set of CDRs for the one or more devices on the wireless network to a billing interface or a billing system (e.g., providing a CDR with a billing offset by account/service). In some embodiments, the CDR storage, aggregation, mediation, feed 118 (and/or other network elements or combinations of network elements) communicates a new set of CDRs for the one or more devices on the wireless network to a billing interface or a billing system. In some embodiments, the CDR storage, aggregation, mediation, feed 118 (and/or other network elements or combinations of network elements) communicates with a service controller to collect the device generated usage information for the one or more devices on the wireless network. In some embodiments, the CDR storage, aggregation, mediation, feed 118 (and/or other network elements or combinations of network elements) communicates with a service controller, in which the service controller is in communication with a billing interface or a billing system. In some embodiments, the CDR storage, aggregation, mediation, feed 118 (and/or other network elements or combinations of network elements) communicates the

device generated usage information to a billing interface or a billing system. In some embodiments, the CDR storage, aggregation, mediation, feed (and/or other network elements or combinations of network elements) communicates with a transport gateway and/or a Radio Access Network (RAN) gateway to collect the network generated usage information for the one or more devices on the wireless network. In some embodiments, the service controller 122 communicates the device generated service usage information to the CDR storage, aggregation, mediation, feed 118 (and/or other network elements or combinations of network elements).

[0048] In some embodiments, the CDR storage, aggregation, mediation, feed 118 (and/or other network elements or combinations of network elements) performs rules for performing a bill by account aggregation and mediation function. In some embodiments, the service controller 122 in communication with the CDR storage, aggregation, mediation, feed 118 (and/or other network elements or combinations of network elements) performs a rules engine for aggregating and mediating the device generated usage information. In some embodiments, a rules engine device in communication with the CDR storage, aggregation, mediation, feed 118 (and/or other network elements or combinations of network elements) performs a rules engine for aggregating and mediating the device generated usage information.

[0049] In some embodiments, the rules engine is included in (e.g., integrated with/part of) the CDR storage, aggregation, mediation, feed 118. In some embodiments, the rules engine and associated functions, as described herein, is a separate function/device. In some embodiments, the service controller 122 performs some or all of these rules engine based functions, as described herein, and communicates with the central billing interface 127. In some embodiments, the service controller 122 performs some or all of these rules engine based functions, as described herein, and communicates with the central billing system 123.

[0050] In some embodiments, duplicate CDRs are sent from the network equipment to the billing system 123 that is used for generating service billing. In some embodiments, duplicate CDRs are filtered to send only those CDRs/records for devices controlled by the service controller and/or service processor (e.g., the managed devices). For example, this approach can provide for the same level of reporting, lower level of reporting, and/or higher level of reporting as compared to the reporting required by the central billing system 123.

[0051] In some embodiments, a bill-by-account billing offset is provided. For example, bill-by-account billing offset information can be informed to the central billing system 123 by providing a CDR aggregator feed that aggregates the device based service usage data feed to provide a new set of CDRs for the managed devices to the central billing interface 127 and/or the central billing system 123. In some embodiments, transaction billing is provided using similar techniques. For example, transaction billing log information can be provided to the central billing interface 127 and/or the central billing system 123.

[0052] In some embodiments, the rules engine (e.g., performed by the service usage 118 or another network element, as described herein) provides a bill-by-account billing offset. For example, device generated usage information (e.g., charging data records (CDRs)) includes a transaction type field (e.g., indicating a type of service for the associated service usage information). The rules engine can apply a rule or a set of rules based on the identified service associated with the device generated usage information to determine a bill-by-account billing offset (e.g., a new CDR can be generated to provide the determined bill-by-account billing offset). In some examples, the determined bill-by-account billing offset can be provided as a credit to the user's service usage account (e.g., a new CDR can be generated with a negative offset for the user's service usage account, such as for network chatter service usage, or transactional service usage, or for any other purposes based on one or more rules performed by the rules engine).

[0053] As another example, for a transactional service, a first new CDR can be generated with a negative offset for the user's service usage account for that transactional service related usage, and a second new CDR can be generated with a positive service usage value to charge that same service usage to the transactional service provider (e.g., Amazon, eBay, or another transactional service provider). In some embodiments, the service controller 122 generates these two new CDRs, and the service usage 118 stores, aggregates, and communicates these two new CDRs to the central billing interface 127. In some embodiments, the service controller 122 generates these two new CDRs, and the service usage 118 stores, aggregates, and communicates these two new CDRs to the central billing interface 127, in which the central billing interface 127 applies rules (e.g., performs the rules engine for determining the bill-by-account billing offset).

[0054] In some embodiments, the service controller 122 sends the device generated CDRs to the rules engine (e.g., service usage 118), and the rules engine applies one or more rules, such as those described herein and/or any other billing/service usage related rules as would be apparent to one of ordinary skill in the art. In some embodiments, the service controller 122 generates CDRs similar to other network elements, and the rules (e.g., bill-by-account) are performed in the central billing interface 127. For example, for the service controller 122 to generate CDRs similar to other network elements, in some embodiments, the service controller 122 is provisioned on the wireless network and behaves substantially similar to other CDR generators on the network) as would be apparent to one of ordinary skill in the art.

[0055] In some embodiments, the service controller 122 is provisioned as a new type of networking function that is recognized as a valid and secure source for CDRs by the other necessary elements in the network (e.g., the Service Usage History/ CDR Aggregation and Mediation Server 118). In some embodiments, in which the network apparatus typically only recognize CDRs from certain types of networking equipment (e.g., RAN Gateway 410 or Transport Gateway 420 (as shown in Figure 3)), then the Service Controller 122 can provide authentication credentials to the other networking equipment that indicate it is one of the approved types of equipment (e.g., for purposes of generating/providing CDRs). In some embodiments, the link between the Service Controller 122 and the necessary CDR aggregation and mediation equipment is secured, authenticated, encrypted and/or signed.

[0056] In some embodiments, the CDR storage, aggregation, mediation, feed 118 discards the network based service usage information (e.g., network based CDRs) received from one or more network elements. In these embodiments, the service controller 122 can provide the device based service usage information (e.g., device based CDRs) to the CDR storage, aggregation, mediation, feed 118 (e.g., the CDR storage, aggregation, mediation, feed 118 can just provide a store, aggregate, and communication function(s)), and the device based service usage information is provided to the central billing interface 127 or the central billing system 123.

[0057] In some embodiments, the device based CDRs and/or new CDRs generated based on execution of a rules engine as described herein is provided only for devices that are

managed and/or based on device group, service plan, or any other criteria, categorization, and/or grouping.

[0058] **Figure 2** illustrates another wireless network architecture for providing device assisted CDR creation, aggregation, mediation and billing in accordance with some embodiments. As shown in Figure 2, some devices 100 are in communication with DOCSIS Head End 125 and some devices 100 are in communication with DSLAM 125, which are in communication with the central provider access network 109.

[0059] **Figure 3** illustrates another wireless network architecture for providing device assisted CDR creation, aggregation, mediation and billing in accordance with some embodiments. Referring now to the 4G/3G/2G access network as shown in Figure 3, the 4G/3G and 3G/2G base stations/nodes 125 are in communication with a 4G/3G/2G Radio Access Network (RAN) gateway 410 via a radio access network 405, which are in communication with a 4G/3G/2G transport gateway 420 via an access transport network 415. The central provider core network 110 is in network communication with the access transport network 415 (e.g., via a dedicated/leased line, and as shown, via a firewall 124). The Internet 120 is available via a firewall 124 and the transport gateway(s) 420, as shown. Also, as shown, a network apparatus provisioning system 160, order management 180, and subscriber management 182 are in communication with the central provider core network 110. As shown, a AAA server 121, a mobile wireless center/Home Location Register(HLR) 132, a DNS/DHCP 126, and CDR storage, aggregation, mediation, feed 118 are also in communication with the access transport network 415. The central billing system 123 and the central billing interface 127 are shown in communication with the central provider core network 110.

[0060] As shown, Figure 3 includes a 4G/3G/2G wireless network operated by, for example, a central provider. In some embodiments, each of the wireless devices 100 includes a service processor 115 (as shown), and each service processor connects through a secure control plane link to a service controller 122. In some embodiments, the network based service usage information (e.g., network generated CDRs) is obtained from Radio Access Network (RAN) gateway(s) 410 and/or transport gateway(s) 420. In some embodiments, device based service usage information (e.g., device assisted CDRs) are generated by the service processor 115 and/or service controller 122 for some or all of the wireless devices 100 using similar techniques as described herein, and in some embodiments, such device based service usage

information (e.g., device assisted CDRs) is sent to the CDR storage, aggregation, mediation, feed 118 (e.g., the CDR storage, aggregation, mediation, feed 118 can just provide a store, aggregate, and communication function(s)), and/or to the central billing interface 127 or the central billing system 123, as similarly described herein with respect to various embodiments.

[0061] **Figure 4** illustrates provisioning of a wireless network for providing device assisted CDR creation, aggregation, mediation and billing in accordance with some embodiments. As shown in Figure 4, the provisioning of various network equipment is provided as shown to recognize each other as an authorized source of CDRs (e.g., this can be done manually or in an automated manner). For example, order management 180, subscriber management, billing interface 127, billing system 123, network provisioning system 160, service controller 122, access network AAA server 121, mobile wireless center 132, and CDR storage, aggregation, mediation feed 118 communicate with each other for such provisioning, which can be implemented using various techniques. In some embodiments, the various network elements are provisioned to recognize device assisted CDRs being generated by the service controller 122, which, for example, can be provided to the billing interface 127 and/or the billing system 123. In some embodiments, network generated CDRs are provided by RAN/Access gateway 410, aggregation/transport gateway 420, and/or base station controller 125. In some embodiments, other network elements generate/receive/store device assisted CDRs.

[0062] In some embodiments, provisioning of various network equipment is provided to recognize a given device as belonging to a device group that supports a service usage and/or billing plan that relies upon and/or utilizes device assisted CDRs.

[0063] In some embodiments, the CDR formats, transaction codes, and CDR transmission destinations are programmed for each device that generates CDRs, including the service controller 122 (e.g., in some embodiments, the service controller 122 is the intermediary for CDRs) and/or service processor 115 (e.g., in some embodiments, the device sends CDRs to network CDR aggregation or billing interface 127/billing system 123 with no intermediate server function).

[0064] **Figure 5** illustrates a network architecture for providing device assisted CDRs in accordance with some embodiments. As shown, network generated CDRs are sent from various network elements to the CDR storage, aggregation, mediation, feed 118 and the service

controller 122, as shown in dashed lines with arrows in Figure 5. In some embodiments, the network generated CDRs are used for verification of device assisted service (DAS) usage and/or billing information. In some embodiments, the network generated CDRs are provided to the service controller 122, and the service controller 122 implements aggregation and/or mediation rules to examine and, in some cases, aggregate and/or mediate network generated/based CDRs with device assisted/based CDRs.

[0065] In some embodiments, device assisted CDRs are sent from the service controller 122 to CDR storage, aggregation, mediation, feed 118 and communicated to the billing system 123, as shown in solid lines with arrows in Figure 5. In some embodiments, CDR storage, aggregation, mediation, feed 118 uses DAS service usage CDRs to augment network generated/based CDRs with bill-by-account transaction codes (e.g., as similarly described herein). In some embodiments, CDR storage, aggregation, mediation, feed 118 implements aggregation and/or mediation rules to account for DAS CDR usage amount in a new bill-by-account transaction code and removes the same service usage amount from the bulk device account transaction code. In some embodiments, a first DAS CDR is sent for the new bill by account transaction code, and a second DAS CDR is sent to be used as a correction (credit) to the main device usage account transaction code, and CDR storage, aggregation, mediation, feed 118 implements the rules to perform this mediation. In some embodiments, a first DAS CDR is used for a given bill-by-account transaction code, and a second DAS CDR is used as the main device account transaction code, in which the service controller 122 (or device) has already implemented the mediation rules so that CDR storage, aggregation, mediation, feed 118 simply passes such DAS CDRs to billing after aggregating them.

[0066] **Figure 6** illustrates another network architecture for providing device assisted CDRs in accordance with some embodiments. Figure 6 also shows the communication of device assisted CDRs and network generated CDRs using solid and dashed lines with arrows, respectively. As shown, in some embodiments, CDR storage, aggregation, mediation, feed 118 sends network based CDRs to service controller 122 for various purposes, such as those previously described herein.

[0067] In some embodiments, service controller 122 sends DAS CDRs to billing for various uses by the billing system 123. In some embodiments, the billing system 123 uses DAS service usage CDRs to augment network based CDRs with bill-by-account transaction

codes. In some embodiments, the billing system 123 implements aggregation and/or mediation rules to account for DAS CDR usage amount in a new bill-by-account transaction code and removes the same service usage amount from the bulk device account transaction code. In some embodiments, a first DAS CDR is sent for the new bill by account transaction code, and a second DAS CDR is sent to be used as a correction (credit) to the main device usage account transaction code, and the billing system 123 implements the rules to perform this mediation. In some embodiments, a first DAS CDR is used for a given bill-by-account transaction code, and a second is used as the main device account transaction code, in which the service controller 122 (or device) has already implemented the mediation rules so that the billing system 123 simply passes such DAS CDRs after aggregating them.

[0068] **Figure 7** illustrates another network architecture for providing device assisted CDRs in accordance with some embodiments. Figure 7 also shows the communication of device assisted CDRs and network generated CDRs using solid and dashed lines with arrows, respectively. Figure 7 is similar to Figure 6, except as shown in Figure 7, service usage information is passed through the billing interface 127 instead of the billing CDR aggregation interface. For example, the service usage detailed bill-by-account information and offset (credit) information can be formatted as a CDR or can be formatted in a higher level syntax as required by the billing interface 127.

[0069] **Figure 8** illustrates another network architecture for providing device assisted CDRs in accordance with some embodiments. Figure 8 also shows the communication of device assisted CDRs and network generated CDRs using solid and dashed lines with arrows, respectively. In some embodiments, as shown in Figure 8, the central provider need not modify the existing CDR storage, aggregation, mediation, feed 118, so the additional aggregation and mediation rules discussed above with respect to Figure 5 are implemented as a new layer of rules in a new network function, shown as secondary DAS CDR aggregation mediation 118A, that is located between the billing system and the CDR storage, aggregation, mediation, feed 118. For example, this new network function (e.g., secondary DAS CDR aggregation mediation 118A) can reside in the network (as shown) or in the service processor 115, in the service controller 122, or elsewhere in the network or on the device.

[0070] **Figure 9** is a functional diagram illustrating a device based service processor 115 and a service controller 122 in accordance with some embodiments. For example, this

provides relatively full featured device based service processor implementation and service controller implementation. As shown, this corresponds to a networking configuration in which the service controller 122 is connected to the Internet 120 and not directly to the access network 1610. As shown, a data plane (e.g., service traffic plane) communication path is shown in solid line connections and control plane (e.g., service control plane) communication path is shown in dashed line connections. As will be apparent, the division in functionality between one device agent and another is based on, for example, design choices, networking environments, devices and/or services/applications, and various different combinations can be used in various different implementations. For example, the functional lines can be re-drawn in any way that the product designers see fit. As shown, this includes certain divisions and functional breakouts for device agents as an illustrative implementation, although other, potentially more complex, embodiments can include different divisions and functional breakouts for device agent functionality specifications, for example, in order to manage development specification and testing complexity and workflow. In addition, the placement of the agents that operate, interact with or monitor the data path can be moved or re-ordered in various embodiments. For example, the functional elements shown in Figure 9 are described below with respect to Figures 10 and 11.

[0071] As shown in Figure 9, service processor 115 includes a service control device link 1691. For example, as device based service control techniques involving supervision across a network become more sophisticated, it becomes increasingly important to have an efficient and flexible control plane communication link between the device agents and the network elements communicating with, controlling, monitoring, or verifying service policy. In some embodiments, the service control device link 1691 provides the device side of a system for transmission and reception of service agent to/from network element functions. In some embodiments, the traffic efficiency of this link is enhanced by buffering and framing multiple agent messages in the transmissions. In some embodiments, the traffic efficiency is further improved by controlling the transmission frequency or linking the transmission frequency to the rate of service usage or traffic usage. In some embodiments, one or more levels of security or encryption are used to make the link robust to discovery, eavesdropping or compromise. In some embodiments, the service control device link 1691 also provides the communications link and heartbeat timing for the agent heartbeat function. As discussed below, various embodiments disclosed herein for the service control device link 1691 provide an efficient and

secure solution for transmitting and receiving service policy implementation, control, monitoring and verification information with other network elements.

[0072] As shown in Figure 9, the service controller 122 includes a service control server link 1638. In some embodiments, device based service control techniques involving supervision across a network (e.g., on the control plane) are more sophisticated, and for such it is increasingly important to have an efficient and flexible control plane communication link between the device agents (e.g., of the service processor 115) and the network elements (e.g., of the service controller 122) communicating with, controlling, monitoring, or verifying service policy. For example, the communication link between the service control server link 1638 of service controller 122 and the service control device link 1691 of the service processor 115 can provide an efficient and flexible control plane communication link, a service control link 1653 as shown in Figure 9, and, in some embodiments, this control plane communication link provides for a secure (e.g., encrypted) communications link for providing secure, bidirectional communications between the service processor 115 and the service controller 122. In some embodiments, the service control server link 1638 provides the network side of a system for transmission and reception of service agent to/from network element functions. In some embodiments, the traffic efficiency of this link is enhanced by buffering and framing multiple agent messages in the transmissions (e.g., thereby reducing network chatter). In some embodiments, the traffic efficiency is further improved by controlling the transmission frequency and/or linking the transmission frequency to the rate of service usage or traffic usage. In some embodiments, one or more levels of security and/or encryption are used to secure the link against potential discovery, eavesdropping or compromise of communications on the link. In some embodiments, the service control server link 1638 also provides the communications link and heartbeat timing for the agent heartbeat function.

[0073] In some embodiments, the service control server link 1638 provides for securing, signing, encrypting and/or otherwise protecting the communications before sending such communications over the service control link 1653. For example, the service control server link 1638 can send to the transport layer or directly to the link layer for transmission. In another example, the service control server link 1638 further secures the communications with transport layer encryption, such as TCP TLS SSH version 1 or 2 or another secure transport layer protocol. As another example, the service control server link 1638 can encrypt at the link

layer, such as using IPSEC, various possible VPN services, other forms of IP layer encryption and/or another link layer encryption technique.

[0074] As shown in Figure 9, the service controller 122 includes an access control integrity server 1654. In some embodiments, the access control integrity server 1654 collects device information on service policy, service usage, agent configuration and/or agent behavior. For example, the access control integrity server 1654 can cross check this information to identify integrity breaches in the service policy implementation and control system. In another example, the access control integrity server 1654 can initiate action when a service policy violation or a system integrity breach is suspected.

[0075] In some embodiments, the access control integrity server 1654 (and/or some other agent of service controller 122) acts on access control integrity agent 1694 reports and error conditions. Many of the access control integrity agent 1654 checks can be accomplished by the server. For example, the access control integrity agent 1654 checks include one or more of the following: service usage measure against usage range consistent with policies (e.g., usage measure from the network and/or from the device); configuration of agents; operation of the agents; and/or dynamic agent download.

[0076] In some embodiments, the access control integrity server 1654 (and/or some other agent of service controller 122) verifies device service policy implementations by comparing various service usage measures (e.g., based on network monitored information, such as by using IPDRs or CDRs, and/or local service usage monitoring information) against expected service usage behavior given the policies that are intended to be in place. For example, device service policy implementations can include measuring total data passed, data passed in a period of time, IP addresses, data per IP address, and/or other measures such as location, downloads, email accessed, URLs, and comparing such measures expected service usage behavior given the policies that are intended to be in place.

[0077] In some embodiments, the access control integrity server 1654 (and/or some other agent of service controller 122) verifies device service policy, and the verification error conditions that can indicate a mismatch in service measure and service policy include one or more of the following: unauthorized network access (e.g., access beyond ambient service policy limits); unauthorized network speed (e.g., average speed beyond service policy limit); network data amount does not match policy limit (e.g., device not stop at limit without re-

up/revising service policy); unauthorized network address; unauthorized service usage (e.g., VOIP, email, and/or web browsing); unauthorized application usage (e.g., email, VOIP, email, and/or web); service usage rate too high for plan, and policy controller not controlling/throttling it down; and/or any other mismatch in service measure and service policy. Accordingly, in some embodiments, the access control integrity server 1654 (and/or some other agent of service controller 122) provides a policy/service control integrity service to continually (e.g., periodically and/or based on trigger events) verify that the service control of the device has not been compromised and/or is not behaving out of policy.

[0078] As shown in Figure 9, service controller 122 includes a service history server 1650. In some embodiments, the service history server 1650 collects and records service usage or service activity reports from the Access Network AAA Server 1621 and the Service Monitor Agent 1696. For example, although service usage history from the network elements can in certain embodiments be less detailed than service history from the device, the service history from the network can provide a valuable source for verification of device service policy implementation, because, for example, it is extremely difficult for a device error or compromise event on the device to compromise the network based equipment and software. For example, service history reports from the device can include various service tracking information, as similarly described above. In some embodiments, the service history server 1650 provides the service history on request to other servers and/or one or more agents. In some embodiments, the service history server 1650 provides the service usage history to the device service history 1618. In some embodiments, for purposes of facilitating the activation tracking service functions (described below), the service history server 1650 maintains a history of which networks the device has connected to. For example, this network activity summary can include a summary of the networks accessed, activity versus time per connection, and/or traffic versus time per connection. As another example, this activity summary can further be analyzed or reported to estimate the type of service plan associated with the traffic activity for the purpose of bill sharing reconciliation.

[0079] As shown in Figure 9, service controller 122 includes a policy management server 1652. In some embodiments, the policy management server 1652 transmits policies to the service processor 115 via the service control link 1653. In some embodiments, the policy management server 1652 manages policy settings on the device (e.g., various policy settings as described herein with respect to various embodiments) in accordance with a device service

profile. In some embodiments, the policy management server 1652 sets instantaneous policies on policy implementation agents (e.g., policy implementation agent 1690). For example, the policy management server 1652 can issue policy settings, monitor service usage and, if necessary, modify policy settings. For example, in the case of a user who prefers for the network to manage their service usage costs, or in the case of any adaptive policy management needs, the policy management server 1652 can maintain a relatively high frequency of communication with the device to collect traffic and/or service measures and issue new policy settings. In this example, device monitored service measures and any user service policy preference changes are reported, periodically and/or based on various triggers/events/requests, to the policy management server 1652. In this example, user privacy settings generally require secure communication with the network (e.g., a secure service control link 1653), such as with the policy management server 1652, to ensure that various aspects of user privacy are properly maintained during such configuration requests/policy settings transmitted over the network. For example, information can be compartmentalized to service policy management and not communicated to other databases used for CRM for maintaining user privacy.

[0080] In some embodiments, the policy management server 1652 provides adaptive policy management on the device. For example, the policy management server 1652 can issue policy settings and objectives and rely on the device based policy management (e.g., service processor 115) for some or all of the policy adaptation. This approach can require less interaction with the device thereby reducing network chatter on service control link 1653 for purposes of device policy management (e.g., network chatter is reduced relative to various server/network based policy management approaches described above). This approach can also provide robust user privacy embodiments by allowing the user to configure the device policy for user privacy preferences/settings so that, for example, sensitive information (e.g., geo-location data, website history) is not communicated to the network without the user's approval. In some embodiments, the policy management server 1652 adjusts service policy based on time of day. In some embodiments, the policy management server 1652 receives, requests or otherwise obtains a measure of network availability and adjusts traffic shaping policy and/or other policy settings based on available network capacity.

[0081] As shown in Figure 9, service controller 122 includes a network traffic analysis server 1656. In some embodiments, the network traffic analysis server 1656 collects/receives service usage history for devices and/or groups of devices and analyzes the service usage. In

some embodiments, the network traffic analysis server 1656 presents service usage statistics in various formats to identify improvements in network service quality and/or service profitability. In other embodiments, the network traffic analysis server 1656 estimates the service quality and/or service usage for the network under variable settings on potential service policy. In other embodiments, the network traffic analysis server 1656 identifies actual or potential service behaviors by one or more devices that are causing problems for overall network service quality or service cost.

[0082] As shown in Figure 9, service controller 122 includes a beta test server 1658. In some embodiments, the beta test server 1658 publishes candidate service plan policy settings to one or more devices. In some embodiments, the beta test server 1658 provides summary reports of network service usage or user feedback information for one or more candidate service plan policy settings. In some embodiments, the beta test server 1658 provides a mechanism to compare the beta test results for different candidate service plan policy settings or select the optimum candidates for further policy settings optimization.

[0083] As shown in Figure 9, service controller 122 includes a service download control server 1660. In some embodiments, the service download control server 1660 provides a download function to install and/or update service software elements (e.g., the service processor 115 and/or agents/components of the service processor 115) on the device, as described herein.

[0084] As shown in Figure 9 service controller 122 includes a billing event server 1662. In some embodiments, the billing event server 1662 collects billing events, provides service plan information to the service processor 115, provides service usage updates to the service processor 115, serves as interface between device and central billing server 1619, and/or provides trusted third party function for certain ecommerce billing transactions.

[0085] As shown in Figure 9, the Access Network AAA server 1621 is in network communication with the access network 1610. In some embodiments, the Access Network AAA server 1621 provides the necessary access network AAA services (e.g., access control and authorization functions for the device access layer) to allow the devices onto the central provider access network and the service provider network. In some embodiments, another layer of access control is required for the device to gain access to other networks, such as the Internet, a corporate network and/or a machine to machine network. This additional layer of

access control can be implemented, for example, by the service processor 115 on the device. In some embodiments, the Access Network AAA server 1621 also provides the ability to suspend service for a device and resume service for a device based on communications received from the service controller 122. In some embodiments, the Access Network AAA server 1621 also provides the ability to direct routing for device traffic to a quarantine network or to restrict or limit network access when a device quarantine condition is invoked. In some embodiments, the Access Network AAA server 1621 also records and reports device network service usage (e.g., device network service usage can be reported to device service history 1618).

[0086] As shown in Figure 9, the device service history 1618 is in network communication with the access network 1610. In some embodiments, the device service history 1618 provides service usage data records used for various purposes in various embodiments. In some embodiments, the device service history 1618 is used to assist in verifying service policy implementation. In some embodiments, the device service history 1618 is used to verify service monitoring. In some embodiments, the device service history 1618 is used to verify billing records and/or billing policy implementation. In some embodiments, the device service history 1618 is used to synchronize and/or verify the local service usage counter.

[0087] As shown in Figure 9, the central provider billing server 1619 is in network communication with the access network 1610. In some embodiments, the central provider billing server 1619 provides a mediation function for central provider billing events. For example, the central provider billing server 1619 can accept service plan changes. In some embodiments, the central provider billing server 1619 provides updates on device service usage, service plan limits and/or service policies. In some embodiments, the central provider billing server 1619 collects billing events, formulates bills, bills service users, provides certain billing event data and service plan information to the service controller 122 and/or device 100.

[0088] As shown in Figure 9, in some embodiments, modem selection and control 1811 selects the access network connection and is in communication with the modem firewall 1655, and modem drivers 1831, 1815, 1814, 1813, 1812 convert data traffic into modem bus traffic for one or more modems and are in communication with the modem selection and control 1811. In some embodiments, different profiles are selected based on the selected network

connection (e.g., different service profiles/policies for WWAN, WLAN, WPAN, Ethernet and/or DSL network connections), which is also referred to herein as multimode profile setting. For example, service profile settings can be based on the actual access network (e.g., home DSL/cable or work network) behind the Wi-Fi not the fact that it is Wi-Fi (or any other network, such as DSL/cable, satellite, or T-1), which is viewed as different than accessing a Wi-Fi network at the coffee shop. For example, in a Wi-Fi hotspot situation in which there are a significant number of users on a DSL or T-1 backhaul, the service controller can sit in a service provider cloud or an MVNO cloud, the service controls can be provided by a VSP capability offered by the service provider or the service controller can be owned by the hotspot service provider that uses the service controller on their own without any association with an access network service provider. For example, the service processors can be controlled by the service controller to divide up the available bandwidth at the hotspot according to QoS or user sharing rules (e.g., with some users having higher differentiated priority (potentially for higher service payments) than other users). As another example, ambient services (as similarly described herein) can be provided for the hotspot for verified service processors.

[0089] In some embodiments, the service processor 115 and service controller 122 are capable of assigning multiple service profiles associated with multiple service plans that the user chooses individually or in combination as a package. For example, a device 100 starts with ambient services that include free transaction services wherein the user pays for transactions or events rather than the basic service (e.g., a news service, eReader, PND service, pay as you go session Internet) in which each service is supported with a bill by account capability to correctly account for any subsidized partner billing to provide the transaction services (e.g., Barnes and Noble may pay for the eReader service and offer a revenue share to the service provider for any book or magazine transactions purchased from the device 100). In some embodiments, the bill by account service can also track the transactions and, in some embodiments, advertisements for the purpose of revenue sharing, all using the service monitoring capabilities disclosed herein. After initiating services with the free ambient service discussed above, the user may later choose a post-pay monthly Internet, email and SMS service. In this case, the service controller 122 would obtain from the billing system 123 in the case of network based billing (or in some embodiments the service controller 122 billing event server 1622 in the case of device based billing) the billing plan code for the new Internet, email and SMS service. In some embodiments, this code is cross referenced in a database (e.g., the policy management server 1652) to find the appropriate service profile for the new service in

combination with the initial ambient service. The new superset service profile is then applied so that the user maintains free access to the ambient services, and the billing partners continue to subsidize those services, the user also gets access to Internet services and may choose the service control profile (e.g., from one of the embodiments disclosed herein). The superset profile is the profile that provides the combined capabilities of two or more service profiles when the profiles are applied to the same device 100 service processor. In some embodiments, the device 100 (service processor 115) can determine the superset profile rather than the service controller 122 when more than one “stackable” service is selected by the user or otherwise applied to the device. The flexibility of the service processor 115 and service controller 122 embodiments described herein allow for a large variety of service profiles to be defined and applied individually or as a superset to achieve the desired device 100 service features.

[0090] As shown in Figure 9, an agent communication bus 1630 represents a functional description for providing communication for the various service processor 115 agents and functions. In some embodiments, as represented in the functional diagram illustrated in Figure 9, the architecture of the bus is generally multipoint to multipoint so that any agent can communicate with any other agent, the service controller or in some cases other components of the device, such user interface 1697 and/or modem components. As described below, the architecture can also be point to point for certain agents or communication transactions, or point to multipoint within the agent framework so that all agent communication can be concentrated, or secured, or controlled, or restricted, or logged or reported. In some embodiments, the agent communication bus is secured, signed, encrypted, hidden, partitioned and/or otherwise protected from unauthorized monitoring or usage. In some embodiments, an application interface agent (not shown) is used to literally tag or virtually tag application layer traffic so that the policy implementation agent(s) 1690 has the necessary information to implement selected traffic shaping solutions. In some embodiments, an application interface agent (not shown) is in communication with various applications, including a TCP application 1604, an IP application 1605, and a voice application 1602.

[0091] In some embodiments, device assisted services (DAS) techniques for providing an activity map for classifying or categorizing service usage activities to associate various monitored activities (e.g., by URL, by network domain, by website, by network traffic type, by application or application type, and/or any other service usage activity

categorization/classification) with associated IP addresses are provided. In some embodiments, a policy control agent (not shown), service monitor agent 1696, or another agent or function (or combinations thereof) of the service processor 115 provides a DAS activity map. In some embodiments, a policy control agent, service monitor agent, or another agent or function (or combinations thereof) of the service processor provides an activity map for classifying or categorizing service usage activities to associate various monitored activities (e.g., by Uniform Resource Locator (URL), by network domain, by website, by network traffic type, by application or application type, and/or any other service usage activity classification/categorization) with associated IP addresses. In some embodiments, a policy control agent, service monitor agent, or another agent or function (or combinations thereof) of the service processor determines the associated IP addresses for monitored service usage activities using various techniques to snoop the DNS request(s) (e.g., by performing such snooping techniques on the device 100 the associated IP addresses can be determined without the need for a network request for a reverse DNS lookup). In some embodiments, a policy control agent, service monitor agent, or another agent or function (or combinations thereof) of the service processor records and reports IP addresses or includes a DNS lookup function to report IP addresses or IP addresses and associated URLs for monitored service usage activities. For example, a policy control agent, service monitor agent, or another agent or function (or combinations thereof) of the service processor can determine the associated IP addresses for monitored service usage activities using various techniques to perform a DNS lookup function (e.g., using a local DNS cache on the monitored device 100). In some embodiments, one or more of these techniques are used to dynamically build and maintain a DAS activity map that maps, for example, URLs to IP addresses, applications to IP addresses, content types to IP addresses, and/or any other categorization/classification to IP addresses as applicable. In some embodiments, the DAS activity map is used for various DAS traffic control and/or throttling techniques as described herein with respect to various embodiments. In some embodiments, the DAS activity map is used to provide the user various UI related information and notification techniques related to service usage as described herein with respect to various embodiments. In some embodiments, the DAS activity map is used to provide service usage monitoring, prediction/estimation of future service usage, service usage billing (e.g., bill by account and/or any other service usage/billing categorization techniques), DAS techniques for ambient services usage monitoring, DAS techniques for generating micro-CDRs (e.g., also referred to as service usage partition, service usage recording partition, service charging

bucket, device generated CDRs, such as in the case where the device and not a network component are generating the usage records, ambient usage records, specialized service usage records, or other terms to indicate a service usage data record generated to provide a more refined or detailed breakdown of service usage for the device), and/or any of the various other DAS related techniques as described herein with respect to various embodiments.

[0092] In some embodiments, all or a portion of the service processor 115 functions disclosed herein are implemented in software. In some embodiments, all or a portion of the service processor 115 functions are implemented in hardware. In some embodiments, all or substantially all of the service processor 115 functionality (as discussed herein) is implemented and stored in software that can be performed on (e.g., executed by) various components in device 100. In some embodiments, it is advantageous to store or implement certain portions or all of service processor 115 in protected or secure memory so that other undesired programs (and/or unauthorized users) have difficulty accessing the functions or software in service processor 115. In some embodiments, service processor 115, at least in part, is implemented in and/or stored on secure non-volatile memory (e.g., non volatile memory can be secure non-volatile memory) that is not accessible without pass keys and/or other security mechanisms. In some embodiments, the ability to load at least a portion of service processor 115 software into protected non-volatile memory also requires a secure key and/or signature and/or requires that the service processor 115 software components being loaded into non-volatile memory are also securely encrypted and appropriately signed by an authority that is trusted by a secure software downloader function, such as service downloader 1663 as shown in Figure 16. In some embodiments, a secure software download embodiment also uses a secure non-volatile memory. Those of ordinary skill in the art will also appreciate that all memory can be on-chip, off-chip, on-board and/or off-board.

[0093] **Figure 10** provides a table summarizing various service processor 115 functional elements in accordance with some embodiments. Many of these agents are similarly described above, and the table shown in Figure 10 is not intended to be an exhaustive summary of these agents, nor an exhaustive description of all functions that the agents perform or are described herein, but rather Figure 10 is provided as a summary aid in understanding the basic functions of each agent in accordance with some embodiments and how the agents interact with one another, with the service controller server elements, and/or with other network

functions in certain embodiments to form a reliable device based service delivery solution and/or platform.

[0094] **Figure 11** provides a table summarizing various service controller 122 functional elements in accordance with some embodiments. Many of these agents/elements are similarly described above, and the table shown in Figure 11 is not intended to be an exhaustive summary of these server elements, nor an exhaustive description of all functions that the elements perform or are described herein, but rather Figure 11 is provided as a summary aid in understanding the basic functions of each element in accordance with some embodiments and how the elements interact with one another, certain network elements, and/or the service processor agents in certain embodiments to form a reliable device based service delivery solution and/or platform.

[0095] **Figure 12** illustrates a device stack providing various service usage measurement from various points in the networking stack for a service monitor agent, a billing agent, and an access control integrity agent to assist in verifying the service usage measures and billing reports in accordance with some embodiments. As shown in Figure 12, several service agents take part in data path operations to achieve various data path improvements, and, for example, several other service agents can manage the policy settings for the data path service, implement billing for the data path service, manage one or more modem selection and settings for access network connection, interface with the user and/or provide service policy implementation verification. Additionally, in some embodiments, several agents perform functions to assist in verifying that the service control or monitoring policies intended to be in place are properly implemented, the service control or monitoring policies are being properly adhered to, that the service processor or one or more service agents are operating properly, to prevent unintended errors in policy implementation or control, and/or to prevent tampering with the service policies or control. As shown, the service measurement points labeled I through VI represent various service measurement points for service monitor agent 1696 and/or other agents to perform various service monitoring activities. Each of these measurement points can have a useful purpose in various embodiments described herein. For example, each of the traffic measurement points that is employed in a given design can be used by a monitoring agent to track application layer traffic through the communication stack to assist policy implementation functions, such as the policy implementation agent 1690, or in some embodiments the modem firewall agent 1655 or the application interface agent, in

making a determination regarding the traffic parameters or type once the traffic is farther down in the communication stack where it is sometimes difficult or impossible to make a complete determination of traffic parameters. The particular locations for the measurement points provided in these figures are intended as instructional examples, and other measurement points can be used for different embodiments, as will be apparent to one of ordinary skill in the art in view of the embodiments described herein. Generally, in some embodiments, one or more measurement points within the device can be used to assist in service control verification and/or device or service troubleshooting.

[0096] In some embodiments, the service monitor agent and/or other agents implement virtual traffic tagging by tracking or tracing packet flows through the various communication stack formatting, processing and encryption steps, and providing the virtual tag information to the various agents that monitor, control, shape, throttle or otherwise observe, manipulate or modify the traffic. This tagging approach is referred to herein as virtual tagging, because there is not a literal data flow, traffic flow or packet tag that is attached to flows or packets, and the book-keeping to tag the packet is done through tracking or tracing the flow or packet through the stack instead. In some embodiments, the application interface and/or other agents identify a traffic flow, associate it with a service usage activity and cause a literal tag to be attached to the traffic or packets associated with the activity. This tagging approach is referred to herein as literal tagging. There are various advantages with both the virtual tagging and the literal tagging approaches. For example, it can be preferable in some embodiments to reduce the inter-agent communication required to track or trace a packet through the stack processing by assigning a literal tag so that each flow or packet has its own activity association embedded in the data. As another example, it can be preferable in some embodiments to re-use portions of standard communication stack software or components, enhancing the verifiable traffic control or service control capabilities of the standard stack by inserting additional processing steps associated with the various service agents and monitoring points rather than re-writing the entire stack to correctly process literal tagging information, and in such cases, a virtual tagging scheme may be desired. As yet another example, some standard communication stacks provide for unused, unspecified or otherwise available bit fields in a packet frame or flow, and these unused, unspecified or otherwise available bit fields can be used to literally tag traffic without the need to re-write all of the standard communication stack software, with only the portions of the stack that are added to enhance the verifiable traffic control or service control capabilities of the standard stack needing to decode and use the literal tagging information

encapsulated in the available bit fields. In the case of literal tagging, in some embodiments, the tags are removed prior to passing the packets or flows to the network or to the applications utilizing the stack. In some embodiments, the manner in which the virtual or literal tagging is implemented can be developed into a communication standard specification so that various device or service product developers can independently develop the communication stack and/or service processor hardware and/or software in a manner that is compatible with the service controller specifications and the products of other device or service product developers.

[0097] It will be appreciated that although the implementation/use of any or all of the measurement points illustrated in Figure 12 is not required to have an effective implementation, such as was similarly shown with respect to various embodiments described herein, various embodiments can benefit from these and/or similar measurement points. It will also be appreciated that the exact measurement points can be moved to different locations in the traffic processing stack, just as the various embodiments described herein can have the agents affecting policy implementation moved to different points in the traffic processing stack while still maintaining effective operation. In some embodiments, one or more measurement points are provided deeper in the modem stack where, for example, it is more difficult to circumvent and can be more difficult to access for tampering purposes if the modem is designed with the proper software and/or hardware security to protect the integrity of the modem stack and measurement point(s).

[0098] Referring to Figure 12, describing the device communications stack from the bottom to the top of the stack as shown, the device communications stack provides a communication layer for each of the modems of the device at the bottom of the device communications stack. Example measurement point VI resides within or just above the modem driver layer. For example, the modem driver performs modem bus communications, data protocol translations, modem control and configuration to interface the networking stack traffic to the modem. As shown, measurement point VI is common to all modem drivers and modems, and it is advantageous for certain embodiments to differentiate the traffic or service activity taking place through one modem from that of one or more of the other modems. In some embodiments, measurement point VI, or another measurement point, is located over, within or below one or more of the individual modem drivers. The respective modem buses for each modem reside between example measurement points V and VI. In the next higher layer, a modem selection & control layer for multimode device based communication is

provided. In some embodiments, this layer is controlled by a network decision policy that selects the most desirable network modem for some or all of the data traffic, and when the most desirable network is not available the policy reverts to the next most desirable network until a connection is established provided that one of the networks is available. In some embodiments, certain network traffic, such as verification, control, redundant or secure traffic, is routed to one of the networks even when some or all of the data traffic is routed to another network. This dual routing capability provides for a variety of enhanced security, enhanced reliability or enhanced manageability devices, services or applications. In the next higher layer, a modem firewall is provided. For example, the modem firewall provides for traditional firewall functions, but unlike traditional firewalls, in order to rely on the firewall for verifiable service usage control, such as access control and security protection from unwanted networking traffic or applications, the various service verification techniques and agents described herein are added to the firewall function to verify compliance with service policy and prevent tampering of the service controls. In some embodiments, the modem firewall is implemented farther up the stack, possibly in combination with other layers as indicated in other Figures. In some embodiments, a dedicated firewall function or layer is provided that is independent of the other processing layers, such as the policy implementation layer, the packet forwarding layer and/or the application layer. In some embodiments, the modem firewall is implemented farther down the stack, such as within the modem drivers, below the modem drivers, or in the modem itself. Example measurement point IV resides between the modem firewall layer and an IP queuing and routing layer. As shown, an IP queuing and routing layer is separate from the policy implementation layer where the policy implementation agent implements a portion of the traffic control and/or service usage control policies. As described herein, in some embodiments, these functions are separated so that a standard network stack function can be used for IP queuing and routing, and the modifications necessary to implement the policy implementation agent functions can be provided in a new layer inserted into the standard stack. In some embodiments, the IP queuing and routing layer is combined with the traffic or service usage control layer. For example, a combined routing and policy implementation layer embodiment can also be used with the other embodiments, such as shown in Figure 12. Measurement point III resides between the IP queuing and routing layer and a policy implementation agent layer. Measurement point II resides between the policy implementation agent layer and the transport layer, including TCP, UDP, and other IP as shown. The session layer resides above the transport layer, which is shown as a socket

assignment and session management (e.g., basic TCP setup, TLS/SSL) layer. The network services API (e.g., HTTP, HTTPS, FTP (File Transfer Protocol), SMTP (Simple Mail Transfer Protocol), POP3, DNS) resides above the session layer. Measurement point I resides between the network services API layer and an application layer, shown as application service interface agent in the device communications stack of Figure 12.

[0099] As shown in Figure 12, the application service interface layer is above the standard networking stack API and, in some embodiments, its function is to monitor and in some cases intercept and process the traffic between the applications and the standard networking stack API. In some embodiments, the application service interface layer identifies application traffic flows before the application traffic flows are more difficult or practically impossible to identify farther down in the stack. In some embodiments, the application service interface layer in this way assists application layer tagging in both the virtual and literal tagging cases. In the case of upstream traffic, the application layer tagging is straight forward, because the traffic originates at the application layer. In some downstream embodiments, where the traffic or service activity classification relies on traffic attributes that are readily obtainable, such as source address or URL, application socket address, IP destination address, time of day or any other readily obtained parameter, the traffic type can be identified and tagged for processing by the firewall agent or another agent as it initially arrives. In other embodiments, as described herein, in the downstream case, the solution is generally more sophisticated when a traffic parameter that is needed to classify the manner in which the traffic flow is to be controlled or throttled is not readily available at the lower levels of the stack, such as association with an aspect of an application, type of content, something contained within TLS, IPSEC or other secure format, or other information associated with the traffic. Accordingly, in some embodiments the networking stack identifies the traffic flow before it is fully characterized, categorized or associated with a service activity, and then passes the traffic through to the application interface layer where the final classification is completed. In such embodiments, the application interface layer then communicates the traffic flow ID with the proper classification so that after an initial short traffic burst or time period the policy implementation agents can properly control the traffic. In some embodiments, there is also a policy for tagging and setting service control policies for traffic that cannot be fully identified with all sources of tagging including application layer tagging.

[00100] As shown in Figure 12, a service monitor agent, which is also in communication with the agent communication bus 1630, communicates with various layers of the device communications stack. For example, the service monitor agent, performs monitoring at each of measurement points I through VI, receiving information including application information, service usage and other service related information, and assignment information. An access control integrity agent is in communication with the service monitor agent via the agent communications bus 1630, as also shown.

[00101] **Figure 13** illustrates an embodiment similar to Figure 12 in which some of the service processor is implemented on the modem and some of the service processor is implemented on the device application processor in accordance with some embodiments. In some embodiments, a portion of the service processor is implemented on the modem (e.g., on modem module hardware or modem chipset) and a portion of the service processor is implemented on the device application processor subsystem. It will be apparent to one of ordinary skill in the art that variations of the embodiment depicted in Figure 13 are possible where more or less of the service processor functionality is moved onto the modem subsystem or onto the device application processor subsystem. For example, such embodiments similar to that depicted in Figure 13 can be motivated by the advantages of including some or all of the service processor network communication stack processing and/or some or all of the other service agent functions on the modem subsystem (e.g., and such an approach can be applied to one or more modems). For example, the service processor can be distributed as a standard feature set contained in a modem chipset hardware or software package or modem module hardware or software package, and such a configuration can provide for easier adoption or development by device OEMs, a higher level of differentiation for the chipset or modem module manufacturer, higher levels of performance or service usage control implementation integrity or security, specification or interoperability standardization, and/or other benefits.

[00102] Referring to Figure 13, describing the device communications stack from the bottom to the top of the stack as shown, the device communications stack provides a communication layer for modem MAC/PHY layer at the bottom of the device communications stack. Measurement point IV resides above the modem MAC/PHY layer. The modem firewall layer resides between measurement points IV and III. In the next higher layer, the policy implementation agent is provided, in which the policy implementation agent is implemented on the modem (e.g., on modem hardware). Measurement point II resides between the policy

implementation agent and the modem driver layer, which is then shown below a modem bus layer. The next higher layer is shown as the IP queuing and routing layer, followed by the transport layer, including TCP, UDP, and other IP as shown. The session layer resides above the transport layer, which is shown as a socket assignment and session management (e.g., basic TCP setup, TLS/SSL) layer. The network services API (e.g., HTTP, HTTPS, FTP (File Transfer Protocol), SMTP (Simple Mail Transfer Protocol), POP3, DNS) resides above the session layer. Measurement point I resides between the network services API layer and an application layer, shown as application service interface agent in the device communications stack of Figure 13.

[00103] **Figure 14** illustrates various embodiments of intermediate networking devices that include a service processor for the purpose of verifiable service usage measurement, reporting, and billing reports in accordance with some embodiments. For example, Figures 14(A) through 14(E) illustrate various extended modem alternatives for access network connection through an intermediate modem or networking device combination that has a connection (e.g., LAN connection) to one or more devices 100.

[00104] In some embodiments, device 100 includes a 3G and/or 4G network access connection in combination with the Wi-Fi LAN connection to the device 100. For example, the intermediate device or networking device combination can be a device that simply translates the Wi-Fi data to the WWAN access network without implementing any portion of the service processor 115 as shown in Figure 14(A). In some embodiments, an intermediate device or networking device combination includes a more sophisticated implementation including a networking stack and some embodiments a processor, as is the case for example if the intermediate networking device or networking device combination includes a router function, in which case the service processor 115 can be implemented in part or entirely on the intermediate modem or networking device combination. The intermediate modem or networking device combination can also be a multi-user device in which more than one user is gaining access to the 3G or 4G access network via the Wi-Fi LAN connection. In the case of such a multi-user network, the access network connection can include several managed service links using multiple instantiations of service processor 115, each instantiation, for example, being implemented in whole or in part on device 100 with the intermediate modem or networking device combination only providing the translation services from the Wi-Fi LAN to the WWAN access network.

[00105] Referring now to Figures 14(B)-(D), in some embodiments, the service processors 115 are implemented in part or in whole on the intermediate modem or networking device combination. In the case where the service processor 115 is implemented in part or in whole on the intermediate modem or networking device combination, the service processor 115 can be implemented for each device or each user in the network so that there are multiple managed service provider accounts all gaining access through the same intermediate modem or networking device combination. In some embodiments, the functions of service processor 115 are implemented on an aggregate account that includes the WWAN access network traffic for all of the users or devices connected to the Wi-Fi LAN serviced by the intermediate modem or networking device combination. In some embodiments, the central provider can also provide an aggregated account service plan, such as a family plan, a corporate user group plan and/or an instant hotspot plan. In the case where there is one account for the intermediate modem or networking device combination, the intermediate modem or networking device combination can implement a local division of services to one or more devices 100 or users in which the services are controlled or managed by the intermediate modem or networking device combination or the device 100, but the management is not subject to service provider control and is auxiliary to the service management or service policy implementation performed by service processors 115. In some embodiments, another service model can also be supported in which there is an aggregate service provider plan associated with one intermediate modem or networking device combination, or a group of intermediate modems or networking device combinations but where each user or device still has its own service plan that is a sub-plan under the aggregate plan so that each user or device has independent service policy implementation with a unique instantiation of service processor 115 rather than aggregate service policy implementation across multiple users in the group with a single instantiation of service processor 115.

[00106] As shown in Figure 14(B), in some embodiments, device 100 includes a Wi-Fi modem, a Wi-Fi modem combined with a 3G and/or 4G WWAN modem on intermediate modem or networking device combination 1510, and the intermediate modem or networking device combination forwards WWAN access network traffic to and from device 100 via the Wi-Fi link. For example, the service processor 115 can be implemented in its entirety on device 100 and the service provider account can be associated exclusively with one device. Similarly, as shown in Figure 14(C), such an implementation can be provided using a different access modem and access network, such as a 2G and/or 3G WWAN, DSL wire line, cable

DOCSIS wire line or fiber wire line configuration in place of the 3G and/or 4G access network connection to the intermediate modem or networking device combination 1510. In addition, various other embodiments similarly use DSL as shown in Figures 14(D), USB, Ethernet, Bluetooth, or another LAN or point to point connection from device 100 to the intermediate modem or networking device combination 1510, or a femto cell modem and DSL/cable/T1/other combination as shown in Figure 14(E).

[00107] **Figure 15** illustrates a wireless network architecture for providing device assisted CDR creation, aggregation, mediation and billing including a proxy server(s) 270 in accordance with some embodiments. As shown, Figure 2 includes a proxy server(s) 270 in communication with a 4G/3G/2G wireless network operated by, for example, a central provider. For example, the proxy server(s) 270 can be used to implement and/or assist in providing various techniques described herein, such as service usage measurement and/or other techniques as described herein.

[00108] In some embodiments, it may not be possible to accurately identify every network service access attempt or service usage (e.g., or traffic access) as belonging to a given service usage partition (e.g., a given ambient service usage, background network chatter usage, user service plan usage, emergency service usage, and/or other type of service usage). As used herein, the terms service usage partition, service usage recording partition, service charging bucket, and micro-CDRs are used interchangeably. Accordingly, it is desirable to provide a service charging bucket for traffic that is allowed and not definitively identified as belonging to a known service charging bucket. This allows for techniques to employ an “allow but verify” approach to traffic that is likely to be legitimately associated with an ambient service or a user service or a network service that is intended to be allowed, but is not definitively identified as being associated with an allowed service.

[00109] As an example, there may be a web site access associated with an ambient service that does not have a reference identifier or other traffic parameter that allows the service processor to associate it with the correct ambient service. In this case, a set of rules can be applied to determine if it is likely that the web site access is a legitimate access given the access control policies that are in place, and if it is the access can be allowed and the traffic usage either recorded in the ambient service charging bucket that it is suspected to be associated with, or the traffic usage can be charged to a network chatter service usage bucket,

or the traffic usage can be charged to the user service usage bucket, or the traffic usage may be recorded in a “not classified but allowed” service charging bucket. In some embodiments, in which such traffic is charged to the “not classified but allowed” service usage charging bucket, additional verification measures are employed to ensure that the amount of traffic that is not classified but allowed does not grow too large or become a back-door for service usage errors. For example, the access control policy rules for allowing unclassified traffic can be relatively loose as long as the amount of service usage charges accumulating in the not classified charging bucket remains within certain bounds, and/or the rate of service usage charged to the not classified bucket remains within certain bounds, but if the not classified traffic becomes large or the rate of not classified traffic growth becomes large then the rules governing when to allow not classified traffic can be tightened.

[00110] As another example, a browser application can access a web site that is known to be an ambient service website, and that web site might serve back a series of traffic flows, some of which are associated with the ambient service website through URL identifiers that are known to be part of the website, and other traffic can be associated with the ambient service website by virtue of a referring website tag or header, and some traffic can be returned to the same application with a relatively close time proximity to the other traffic as being identified as ambient traffic. In this example, as long as the not classified traffic service charging bucket does not exceed a given pre-set policy limit on its size, and/or does not grow faster than a given pre-set policy rate, and/or is received within a certain pre-set policy period of time difference from the time that other ambient service charging bucket traffic is received, then the not classified traffic is continued to be allowed. However, if the not classified traffic amount or rate of growth exceeds the pre-set policy limits, or if the period of time between when verified ambient service traffic is received and the not classified traffic is received exceeds policy limits, then the not classified traffic can be blocked or other action can be taken to further analyze the not classified traffic.

[00111] In some embodiments, it is important to provide a hierarchy of service usage charging rules for the various service usage partitions on a device. As an example, for a given service plan there can be two ambient service charging buckets, a network chatter (e.g., or network overhead) service charging bucket, and a user service plan service charging bucket and it is desirable to make sure that no ambient services or network overhead service or unclassified service is charged to the user service plan, and it is also desirable to ensure that all

known ambient service traffic is charged to the appropriate ambient service partner, and it is desirable to ensure that no network overhead service or unclassified service is charged to ambient service partners. In such situations, a service charging bucket hierarchy can be provided as follows: determine if a traffic flow (e.g., or socket) is associated with network overhead, and if so allow it and charge that service bucket, then determine if a traffic flow (or socket) is associated with ambient service #1, and if so allow it and charge that service bucket, then determine if a traffic flow (or socket) is associated with ambient service #2, and if so allow it and charge that service bucket, then determine if a traffic flow (or socket) is associated with not classified traffic, and if so allow it and charge that service bucket, then if the traffic is not associated with any of the above service charging buckets allow it and charge it to the user service plan charging bucket. In another example, if the user has not yet chosen to pay for a user service plan, then the same hierarchical access control and service charging policy can be used except the final step would be: then if the traffic is not associated with any of the above service charging buckets block the traffic. Hierarchical service charging bucket identification such as depicted in these examples can be a crucial aspect of a robust access control policy and/or service charging policy system. Many other access control policy hierarchies and service charging bucket policy hierarchies will now be apparent to one of ordinary skill in the art.

[00112] In some embodiments, the not classified traffic is charged according to service charging rules that rely on the most likely candidate service charging bucket for the traffic. As another example, if the not classified traffic is being delivered to the same application as other known ambient service traffic and the time difference between delivery of the known ambient service traffic and the not classified traffic is small, then the not classified traffic can be charged to the ambient service in accordance with a pre-set charging policy rule specifying these conditions. Other embodiments that will now be apparent to one of ordinary skill in the art. For example, another charging rule for not classified traffic could be to perform a pro-rata allocation of the not classified traffic to all of the other service charging buckets with the pro-rata allocation being based on the percentage of the total traffic used by the device for each service charging bucket. As another example, the not classified traffic can be charged to a subset of the service charging buckets for the device (e.g., all ambient services plus the network overhead service) in accordance with the pro-rata share for each service included in the pro-rata split.

[00113] In some embodiments, the user service plan agreement is structured so that the user acknowledges that ambient services in which the access connection to the service is sponsored, paid for, and/or partially subsidized by an entity other than the user are a benefit to the user, and/or the user acknowledges that there is no inherent right to free ambient services, and that the service usage accounting system may not always properly characterize usage for a sponsored or subsidized ambient service (e.g., or some other specialized service) in the correct accounting service charging bucket, and, thus, the user service plan account can be charged and/or billed with some of this traffic. By having the user acknowledge a service use agreement of this form then some ambient traffic can be charged to the user service plan account, including, for example, allowed but not classified traffic, excess ambient service usage beyond pre-set policy limits, ambient service usage during busy network periods or on congested network resources, and/or other criteria/measures. In some embodiments, the user might be notified that they are being charged for service activities that are sometimes subsidized or free to the user. As discussed above, it is important to ensure that a not classified service charging bucket does not become a back door for service charging errors or hacking. It will now be apparent to one of ordinary skill in the art that the not classified service usage charges can be verified in a variety of manners, including, for example, observing the size of the not classified service charging bucket as compared to other service usage charges on the device (e.g., total device service usage, ambient service usage, user bucket service usage, and/or other criteria/measures), capping the not classified bucket, and/or capping the rate of growth of the not classified bucket.

[00114] In some embodiments, it is important to verify not only that the total device service usage amount is correct, but that the service usage is being reported in the proper service charging buckets. For example, if the service processor software can be hacked so that it correctly reports the total service usage, but reports user service plan traffic under one or more ambient service buckets, then simply verifying that the total amount of service usage is correct will not be sufficient to prevent the device from obtaining free user service that can be charged to ambient service partners. There are a variety of direct and indirect embodiments to accomplish this verification of service charging bucket divisions. For example, in direct verification embodiments, one or more alternative measures of service usage are employed to cross-check the accuracy of the service charging bucket divisions. In indirect embodiments one of two classes of verification are employed: the size and rate of growth for service charging buckets is analyzed and compared to a pre-set group of policies to detect and/or

modify service charging bucket growth that is out of policy; and/or the proper operation of the service processor elements involved in service charging bucket partitioning is verified.

[00115] Various embodiments involving direct verification of service charging bucket usage and/or accounting include the use of network based service usage measures such as CDRs, IPDRs, flow data records (e.g., FDRs – detailed reports of service usage for each service flow, such as network socket connection, opened and used to transmit data to or from the device), accounting records, interim accounting records or other similar usage records to verify that the device is within service policy and/or the device based service usage reports are accurate. Use of such network generated service usage records to directly verify service charging and/or proper service usage policy adherence are described herein. When network address destination and/or source information is available in these records, as described herein, this can be used in some embodiments to verify the service charging bucket accounting provided by the device service processor. In some embodiments, some types of service usage records include real-time data but not necessarily all of the useful information needed to help verify service charging bucket accounting, while other types of service usage records provide more detail (e.g., IP address for destination and source) but do not always arrive in real-time. For example, in some embodiments, FDRs are created each time a new service flow (e.g., network socket connection) is opened and then closed. At the time the service flow is closed, a (e.g., possibly time stamped) data usage record indicating source address, destination address and amount of data transmitted is created and sent to a charging aggregation function in the network. The charging aggregation function can then forward the FDRs to the service controller for verification or direct accounting of service charging bucket accounting. By comparing the FDR addresses with known ambient service traffic address associations, the partitioning of service charging buckets between one or more ambient services and other services such as a user service plan service charging bucket may be verified. However, in some cases it can be a long period of time for an FDR to be generated when a device service flow (e.g., socket) remains open for a long period of time, as in the case for example with a long file download, a peer to peer connection with a socket keep alive, or a proxy server service with a socket keep alive. In such cases, it can be disadvantageous to have large amounts of data to be transferred without an FDR to confirm device service processor based reports, and in some cases this can provide an opportunity for service processor service reporting hacks. This can be remedied in a variety of ways by using other network reported service usage information to augment the FDR information. For example, start and stop

accounting records can sometimes be obtained in some embodiments from a network element such as a service gateway or the AAA servers (e.g., or other network equipment elements depending on the network architecture). Although start and stop records do not possess the detail of service usage information that FDRs, CDRs, IPDRs, interim accounting records or other service usage records possess, they do inform the service controller that a device is either connected to the network or has stopped connecting. If a device is connected to the network and is not transmitting device usage reports or heartbeats, then the service controller is alerted that an error or hacking condition is likely. As another example of how two or more types of network reported service usage information may be used to create a better real time or near real-time check on device service usage, if both FDRs and start/stop accounting records are available, the service controller can send a stop-then-resume service command to the device (e.g., or alternatively send a stop then resume service command to a network equipment element), which will cause the device to terminate all open service flows before re-initiating them, and once the service flows are stopped then the FDR flow records will be completed and transmitted for any service flows that were in process but unreported when the stop service command was issued. This will cause any long term open socket file transfers to be reported in the FDR flow records thus plugging the potential back door hole in the FDR service usage accounting verification method.

[00116] As another example showing how multiple types of network generated service usage accounting records may be used to complement each other and strengthen the verification of service charging bucket accounting partitions, interim data records can be used with FDRs. Interim data records are available in accordance with some embodiments, in which the interim data records are generated on a regularly scheduled basis by a network element (e.g., gateway, base station, HLR, AAA, and/or other network element/function). Interim data records are typically near real time records that report the aggregate traffic usage for the device as of a point in time, but often do not include traffic address information or other traffic details. In embodiments in which both interim accounting records and FDRs are available, when the interim accounting records are indicating service usage that is not being reported in the FDR stream this is evidence that a device has one or more long term socket connections that are open and are not terminating. In this case, the service controller can verify that the device based usage reports are properly accounting for the total amount of service usage reported by the interim accounting records, and/or the service controller can force an FDR report for the open sockets by issuing a stop-resume service command as similarly discussed above.

[00117] As described herein, other embodiments involving direct verification of service charging bucket accounting can be provided. One example is to route ambient service traffic to a proxy server or router programmed to support only the network access allowed for the ambient service and to account for the ambient service usage. Additional proxy servers or routers can be similarly programmed for each ambient service that is part of the device service plan, and in some embodiments, another proxy server or router is programmed to support traffic control and account for the user service plan service access. By comparing the service usage accounting for each of these proxy servers or routers, the device generated service charging bucket accounting can be directly verified. In some embodiments, the usage accounting provided by the proxy servers or routers is used directly for service usage accounting.

[00118] In some embodiments, ambient service partner feedback is used to verify service charging bucket accounting. For example, web servers used by ambient service partners to provide ambient services can identify a user device based on header information embedded in the HTML traffic, and then account for either the service used by the device during the ambient service sessions or account for the number of transactions the user completes. If service usage is recorded, then it can be reported to the service controller and be used directly to verify ambient service charging bucket accounting. If transactions are all that are recorded, then this can be reported to the service controller and the amount of ambient service used by the device can be compared with the number of transactions completed to determine if the ambient service usage is reasonable or should be throttled or blocked. It will now be apparent to one of ordinary skill in the art that other embodiments can be provided that employ more than one type of network generated service usage records to verify service usage accounting and/or verify service charging bucket accounting.

[00119] Other embodiments involving indirect methods for verifying or controlling service charging bucket accounting include monitoring the size and/or growth rate of ambient service usage. In some embodiments, the access control policy rules call for restricting a given ambient service access when the amount of service usage charges accumulating in the ambient service charging bucket exceed a pre-set policy limit, and/or when the rate of service usage for the ambient service exceeds a pre-set policy limit. For example, once these limits are reached, the ambient service can be throttled back for a period of time, blocked for a period of time, or charged to the user service plan charging bucket. In some embodiments, before these actions

are taken the user UI can be used to notify the user of the service policy enforcement action. In some embodiments, indirect verification of service charging bucket accounting includes the various techniques described herein for verifying proper operation of the service processor agent software and/or protecting the service processor agent software from errors, manipulation, or hacking.

[00120] In some embodiments, the device service processor directs traffic destined for a given ambient service to a proxy server or router programmed to support that ambient service, and any traffic control policies and/or access control policies for the ambient service are implemented in the proxy server or router. For example, in such embodiments the proxy server or router can be programmed to only allow access to one or more ambient services that are authorized by the device service plan, with the proxy server or router controlling device access so that other network destinations cannot be reached. Continuing this example embodiment, the proxy server or router can account for the ambient service usage in an ambient service charging bucket as discussed elsewhere. In such proxy server or router ambient service control embodiments, the same traffic association techniques described elsewhere that allow incoming traffic associated with an ambient service website or other service to be identified, allowed or blocked, potentially throttled, and accounted for in a service charging bucket can be implemented in the proxy server or router programming. Such proxy server or router embodiments can also implement user service plan service charging buckets, user service plan traffic controls, and user service plan access control as discussed herein. In some embodiments, the proxy server or router analyzes the HTML traffic content of the traffic flows as described herein to perform such associations, traffic control and/or service usage accounting. Similarly, in some embodiments, a proxy server or router can provide the “surf-out” capabilities described herein by performing the same surf-out traffic associations (e.g., HTML branch reference associations and/or other branch associations) described herein. It will now be apparent to one of ordinary skill in the art that many of the adaptive ambient service control and service usage charging functions described herein for a service processor can be readily implemented with a proxy server or router that is appropriately programmed.

[00121] In some embodiments, routing of device traffic for one or more ambient services and/or user service plan services to a proxy server or router is accomplished by the device service processor using the device service processor traffic control embodiments described herein. In some embodiments, routing of device traffic for one or more ambient

services and/or user service plan services to a proxy server or router is accomplished by dedicated network equipment such as the gateways (e.g. SGSN, GGSN, PDSN, or PDN), home agents, HLRs or base stations, with the network equipment being provisioned by a service controller (e.g., or other interchangeable network element with similar functions for this purpose) to direct the device traffic to the proxy server or router. In some embodiments, the ambient service traffic or the user service plan traffic is controlled by the proxy server according to a service plan policy set supplied by the service controller (e.g., or equivalent network function for this purpose). The traffic control service policy thus implemented by the proxy server can control traffic based on one or more of the following: period of time, network address, service type, content type, application type, QoS class, time of day, network busy state, bandwidth, and data usage.

[00122] In some embodiments, a proxy server or router is used to verify accounting for a given service, for example, an ambient service. In some embodiments, this is accomplished by the device service processor directing the desired service flows to a proxy server or router programmed to handle the desired service flows, with the proxy server or router being programmed to only allow access to valid network destinations allowed by the access control policies for the desired service, and the proxy server or router also being programmed to account for the traffic usage for the desired services. In some embodiments, the proxy service usage accounting may then be used to verify device based service usage accounting reported by the service processor. In some embodiments, the accounting thus reported by the proxy server or router can be used directly to account for service usage, such as ambient service usage or user service plan service usage.

[00123] In some embodiments, in which a proxy server is used for device service usage accounting, the proxy server maintains a link to the device service notification UI via a secure communication link, such as the heartbeat device link described herein. For example, the proxy server or router can keep track of device service usage versus service plan usage caps/limits and notify the user device UI through the device communication link (e.g., heartbeat link) between the service controller and the device. In some embodiments, the proxy server/router communicates with a device UI in a variety of ways, such as follows: UI connection through a device link (e.g., heartbeat link), through a device link connected to a service controller (e.g., or other network element with similar function for this purpose), presenting a proxy web page to the device, providing a pop-up page to the device, and/or

installing a special portal mini-browser on the device that communicates with the proxy server/router. In some embodiments, the UI connection to the proxy server/router is used as a user notification channel to communicate usage notification information, service plan choices, or any of the multiple services UI embodiments described herein.

[00124] In some embodiments for the proxy server/router techniques for implementing service traffic/access controls and/or service charting bucket accounting, it is desirable to have the same information that is available to the service processor on the device, including, for example, application associated with the traffic, network busy state, QoS level, or other information about the service activity that is available at the device. For example, such information can be used to help determine traffic control rules and/or special services credit is due (e.g., ambient services credit). In some embodiments, information available on the device can be communicated to the proxy server/router and associated with traffic flows or service usage activities in a variety of ways. For example, side information can be transmitted to the proxy server/router that associates a traffic flow or service activity flow with information available on the device but not readily available in the traffic flow or service activity flow itself. In some embodiments, such side information may be communicated over a dedicated control channel (e.g., the device control link or heartbeat link), or in a standard network connection that in some embodiments can be secure (e.g., TLS/SSL, or a secure tunnel). In some embodiments, the side information available on the device can be communicated to the proxy server/router via embedded information in data (e.g., header and/or stuffing special fields in the communications packets). In some embodiments, the side information available on the device can be communicated to the proxy server/router by associating a given secure link or tunnel with the side information. In some embodiments, the side information is collected in a device agent or device API agent that monitors traffic flows, collects the side information for those traffic flows, and transmits the information associated with a given flow to a proxy server/router. It will now be apparent to one of ordinary skill in the art that other techniques can be used to communicate side information available on the device to a proxy server/router.

[00125] For example, just as the hierarchy of charging rules can be important for implementations in which the service processor is creating the service charging bucket accounting, it can also be important in implementations that use a proxy server or router for service charging bucket accounting. Accordingly, various embodiments described herein for

creating a hierarchy of service usage charging rules can be applied to proxy server or proxy router embodiments. It will be apparent to one of ordinary skill in the art that the service charging bucket embodiments and traffic control and access control embodiments described herein for allowed but not classified buckets apply equally to the proxy server/router embodiments. For example, pre-defined service policy rules can be programmed into the proxy server/router to control the traffic flows and/or place usage limits or access limits on an ambient service, or a user service plan service. It will also now be apparent to one of ordinary skill in the art that the embodiments described herein disclosing an initial allowed service access list, temporarily allowing additional service activities until they are determined to be allowed or not allowed, expanding the allowed service activity list, maintaining a not allowed service activity list and expanding the not allowed service activity list also apply equally to proxy server/router embodiments. Similarly, it will now be apparent to one of ordinary skill in the art that the proxy/server router embodiments can be employed to directly generate the service charging bucket (or micro-CDR) usage reports used to provide further detail and/or billing capabilities for service usage. In some embodiments, in which the device service processor directs traffic to a proxy server/router, there are advantageous design feature embodiments available that can reduce the need to provision network to detect and force specialized device service traffic to the appropriate proxy server/router. For example, this can be done by creating a "usage credit" system for the services supported by the proxy server/router. Total service usage is counted on the one hand by the device service processor, or by other network equipment, or by both. Credit on the other hand for ambient service or other specialized access service usage that is not charged to the user is then provided for services that the device directs through the proxy server/router destination (e.g., URL or route hop) supporting the particular ambient service or other specialized access service. If the device correctly directs traffic to the proxy server/router, then the counting and/or access rules are correctly implemented by the proxy server/router. The service can be thus controlled and/or accounted for. When the service is accounted for, the proxy server/router reports the service charging bucket accounting back to the service controller (e.g., or other network equipment responsible for service charging bucket/ micro CDR mediation) and the user service plan service charging bucket account can be credited for the services. Traffic that reaches the proxy server/router is controlled by the access rules and/or traffic control rules and/or QoS control rules of the proxy server/router programming, so there is no question regarding the type of service that is supported with the service charging buckets that are reported to mediation

functions (e.g., mediation functions can be performed by one or more of service controller, usage mediation, billing, AAA, and/or HLR/home agent). As the proxy server/router is in the network and can be physically secured and protected from hacking, there is high confidence that the service control and/or charging rules intended for ambient services or some other specialized service are properly implemented and that the proxy server/router connection is being used for the intended service and not some other unintended hacked service. If the device is somehow hacked or otherwise in error so that the traffic is not directed through the appropriate proxy server/router, then the proxy server/router does not log the traffic in micro CDRs/buckets and no specialized service usage credit is sent to the mediation functions, so there is no usage credit deducted from the device user service plan service usage totals. Thus, the user pays for the services when the device is hacked to avoid the proxy server/router. The user account service agreement can specify that if the user tampers with software and traffic is not routed to servers then credit will not be provided and user plan will be charged.

[00126] In some proxy server/router embodiments, the usage credit is sometimes recorded by the proxy server/router detecting which device is performing the access. Device identification can be accomplished in a variety of ways including a header/tag inserted into the traffic by the device, a route in the network specified for that device, a secure link (e.g., TLS/SSL, IP Sec, or other secure tunnel), a unique device IP address or other credential (e.g., where proxy server/router has access to an active IP address look up function), a unique proxy server/router address and/or socket for the device.

[00127] In some embodiments, the coordination of the device service controller traffic control elements with a proxy server/router can make it simpler to locate, install, provision and operate the proxy servers. The proxy server/routers do not need to be located “in line” with the access network because it is the device's responsibility to make sure the traffic is routed to the servers/routers or else there is not credit and the user account is charged. In some embodiments, this makes it unnecessary or reduces the need to force device traffic routes in carrier network. In some embodiments, the proxy server/routers can be located in carrier network or on the Internet. If the proxy server/routers are on Internet, then traffic can be authenticated in a firewall before being passed to server/routers to enhance security to attack.

[00128] In some embodiments, the service charging bucket recording software in the proxy server/router can be programmed into an ambient service partners network equipment

directly thus eliminating the need for special apparatus. The ambient service partner's equipment (e.g., a web server, load balancer or router) can recognize the device using one of the techniques described above, aggregate the device service charging bucket accounting, and periodically send the usage accounting to the service controller or other network service usage mediation function.

[00129] Programming and/or provisioning the types of ambient services, user service plan services and/or specialized services disclosed in various embodiments described herein can be a complex process. In some embodiments, a simplified user programming interface, also referred to herein as a service design interface, is used to program the necessary policy settings for such services is desirable. For example, a service design interface is provided that organizes and/or categorizes the various policy settings that are required to set up an ambient service (e.g., or other service) including one or more of the following: a policy list of service activities that are allowed under the ambient service (e.g., or other service), access control policies, rules for implementing and/or adapting an allowed list of network destinations, rules for implementing and/or adapting a blocked list of network destinations, service charging bucket policies, user notification policies, service control, and/or service charging bucket verification policies, actions to be taken upon verification errors. In some embodiments, the required information for one or more of these policy sets is formatted into a UI that organizes and simplifies the programming of the policies. In some embodiments, the UI is partly graphical to help the user understand the information and what settings need to be defined in order to define the service. In some embodiments, the UI is created with an XML interface. In some embodiments, the UI is offered via a secure web connection. In some embodiments, a basic service policy for an ambient service (e.g., or another service) is created that includes one or more of the above service policy settings, and then this service policy set becomes a list or an object that can be replicated and used in multiple service plan policy set definitions (e.g., "dragged and dropped" in a graphical UI). In some embodiments, the resulting set of policies created in this service design interface are then distributed to the necessary policy control elements in the network and/or on the device that act in coordination to implement the service policy set for a given device group. For example, if a service processor is used in conjunction with a service controller, then the service design interface can load the service policy settings subsets that need to be programmed on the service controller and the device service processor into the service controller, and the service controller loads the service controller policy settings subset into the service controller components that control the policies and loads the device

policy settings subset to the devices that belong to that device group. In embodiments in which a proxy server/router is used to help control and account for services, in some embodiments, the service design interface loads the service policy settings subsets that need to be programmed on the proxy server/router into the proxy server/router. In embodiments where other network equipment (e.g., gateways, base stations, service usage recording/aggregation/feed equipment, AAA, home agent/HLR, mediation system, and/or billing system) need to be provisioned or programmed, in some embodiments, the service design interface also loads the appropriate device group policy subsets to each of the equipment elements. Accordingly, various techniques can be used as described herein to greatly simplify the complex task of translating a service policy set or service plan into all the myriad equipment and/or device settings, programming, and/or provisioning commands required to correctly implement the service. It will now be apparent to one of ordinary skill in the art that several of these techniques can similarly be used for the VSP service design interface.

[00130] Those of ordinary skill in the art will appreciate that various other rules can be provided for the rules engine as described herein. Those of ordinary skill in the art will also appreciate that the functions described herein can be implemented using various other network architectures and network implementations (e.g., using various other networking protocols and corresponding network equipment and techniques).

[00131] **Figure 16** illustrates examples of service controller interfaces that may be used to facilitate communications to and from service controller 122. As shown in Figure 16, end-user device 100 is equipped with service processor 115 and is capable of supporting device-assisted services.

[00132] Some interfaces shown in Figure 16 allow service controller 122 to receive information. Examples include device identification list interface 2010, service provisioning updates interface 2020, usage report interface 2030, and flow data record (FDR) report interface 2040. Other interfaces shown in Figure 16 allow service controller 122 to deliver information or make requests. For example, these interfaces may include one or more of subscriber onboarding interface 2050, carrier data record (CDR) interface 2060, service provisioning request interface 2070, FDR request interface 2080, fraud alert interface 2090, and customer alert acknowledgment interface 2100.

[00133] As illustrated in Figure 16, service controller 122 also has various interfaces that allow it to communicate with end-user device 100. For example, policy interface 2110 (or service control device link 1691, service control server link 1638, or other another interface) allows service controller 122 to send a policy or other information to service processor 115. As another example, usage record service selection interface 2120 allows service controller 122 to receive usage data records from end-user device 100.

[00134] As would be appreciated by a person having ordinary skill in the art, the interfaces shown in Figure 16 are conceptual and exemplary. The interfaces illustrated in Figure 16 are not necessarily an exhaustive or complete set of interfaces. The interfaces illustrated in Figure 16 do not necessarily correspond to different physical interfaces. The physical interfaces may be unidirectional or bidirectional. Moreover, a single physical interface may support more than one of the interfaces shown in Figure 16.

[00135] Possible uses of the exemplary interfaces shown in Figure 16 are now described in more detail.

[00136] **Uniform Interfaces for On-Device Service Selection**

[00137] On-device user selection or purchase of a network service plan offered to an end user through a device user interface agent (e.g., a service processor client software or firmware agent configured with a service plan selection user interface function) can be difficult to implement because different wireless service provider networks often have different service plan provisioning systems or different service plan activation systems. This circumstance can make it difficult to create a consistent user experience for selecting or purchasing a service plan on a device because different carrier networks can have different service plan selection or purchase processes. This can also make it difficult to develop a consistent device service selection or purchase user interface agent (e.g., a service processor software or firmware agent that supports on-device service plan selection or purchase via an end-user device user interface) because differences between wireless networks can cause differences in service plan selection or purchase interfaces to the network, which in turn cause differences in the required end-user device agent (e.g., service processor) design or service selection interface. It is therefore desirable to create a uniform wireless network service selection information exchange interface system.

[00138] An example service selection/provisioning workflow for network-based service policy control and an on-device user interface with service plan selection or service plan purchase capability is now described using the embodiment illustrated in Figure 16. A user of end-user device 100 initiates a device activity that triggers a service plan options notice informing the end user that one or more service plan options are available to the end user for service plan selection or service plan purchase. The end user elects to view the service plan options. Service processor 115 on end-user device 100 sends the service selection information request to service controller 122. The service selection information request includes information about end-user device 100, including, in some embodiments, device credentials. After receiving the service selection information request via usage record service selection interface 2120, service controller 122 sends a message requesting information about available service plans to the network over service provisioning request interface 2070. Service controller 122 then receives from the network, through service provisioning update interface 2020, an update for the available service plans associated with end-user device 100 (e.g., the service plans available for the device group or user group that includes device credentials for end-user device 100). Based on the update of the available service plans, service controller 122 generates a service plan offer set for end-user device 100. Service controller 122 sends the service plan offer set to service processor 115 via policy interface 2110 (or service control device link 1691, service control server link 1638, or another interface). Service processor 115 displays the service plan offer set to the end user via a user interface (not shown) on end-user device 100. The end user selects one or more service plans, and service processor 115 transmits the service selection to service controller 122. After receiving the service selection via usage record service selection interface 2120, service controller 122 sends a service selection message to the network over service provisioning request interface 2070. Network provisioning system 160 (shown in several figures, including Figure 1) then provisions or activates the selected service plan (possibly in conjunction with billing system 123, subscriber management 182, or order management 180) and sends service controller 122 a service plan activation confirmation through service provisioning update interface 2020. Service controller 122 then sends service processor 115 a service plan confirmation that is in turn presented to the user through a user interface on the end-user device.

[00139] In some embodiments, a uniform wireless network service selection interface system comprises a uniform service plan selection, service plan activation, or service plan purchase information exchange that facilitates communication of user service plan selection

options or user service plan selection choices between an end-user device interface agent capable of displaying service options to a user and accepting service selections from the device user (e.g., using a service processor) and one or more network elements that facilitate service plan provisioning, service plan activation, or service plan purchase (e.g., network provisioning system 160, billing system 123, subscriber management 182, or order management 180).

[00140] In some embodiments, a uniform wireless network service selection interface system comprises uniform service provisioning update interface 2020. In some embodiments, the uniform wireless network service selection interface system includes a service controller that implements service provisioning update interface 2020. In some embodiments, a service controller includes a service provisioning update interface 2020 that comprises a uniform service plan selection, service plan activation, or service plan purchase information exchange for communication of user service plan selection options between a wireless network element (e.g., network provisioning system 160, billing system 123, subscriber management 182, or order management 180) and the service controller. In some embodiments service provisioning update interface 2020 comprises a uniform service plan selection, service plan activation, or service plan purchase information exchange for communication of user service plan selection options between a wireless network element (e.g., network provisioning system 160, billing system 123, subscriber management 182, or order management 180) and a service controller in a manner that maintains a consistent interface for multiple wireless networks. In some embodiments, the service controller service plan information exchange protocols used in service provisioning update interface 2020 are used to communicate with a common service selection information exchange protocol across multiple wireless networks. In some embodiments, a service controller implements a uniform service plan selection exchange protocol for service plan selection communication with a device service processor, wherein the uniform service plan selection exchange protocol is consistent across multiple wireless networks. In this way, service controller 122 can provide a uniform translation function that allows an on-device service selection agent (e.g., service processor 115) to interface with the network in a consistent manner to provide a consistent user experience with multiple wireless networks that may have different service plan activation or service plan purchase processes.

[00141] In some embodiments, implementing service provisioning update interface 2020 comprises implementing a uniform information exchange protocol in a service controller, wherein the formatting of service plan selection option information or service plan purchase

option information is defined in the protocol. In some embodiments, the pre-defined protocol employed in service provisioning update interface 2020 for service plan selection option information or service plan purchase option information communicates one or more service plan selection options or one or more service plan purchase options from a wireless network element (e.g., network provisioning system 160, billing system 123, subscriber management 182, or order management 180) to a service controller.

[00142] In some embodiments a service controller communicates the service plan selection options or service plan purchase options to an end-user device service selection user interface function (e.g., using a service processor configured to communicate with a service selection user interface). In some embodiments, service controller 122 translates the service plan selection option or service plan purchase option so that it is compatible with a uniform service plan selection information exchange protocol used between service controller 122 and service processor 115. In some embodiments, service controller 122 communicates the service plan selection options or service plan purchase options to a service processor 115 (e.g., on end-user device 100, which is also configured with a service selection user interface) via policy interface 2110 (or service control device link 1691, service control server link 1638, or another interface). In some embodiments, policy interface 2110 comprises a uniform service plan selection, service plan activation, or service plan purchase information exchange configured to communicate user service plan selection options or service plan purchase options between service controller 122 and service processor 115. In some embodiments, service controller 122 communicates the service plan selection options or service plan purchase options to service processor 115 via a uniform service plan selection, service plan activation, or service plan purchase information exchange, such as policy interface 2110 (or service control device link 1691, service control server link 1638, or another interface), that maintains consistent protocols across multiple wireless networks. In this manner, a network element such as service controller 122 can provide a consistent interface across one or multiple networks to allow device agents or device applications to receive service plan selection options or service plan purchase options for display to an end-user device user interface.

[00143] In some embodiments, service processor 115 has a user interface that is capable of presenting one or more of the service plan selection options or service plan purchase options to the end user so that the end user may select a service plan. In some embodiments, the user then selects one of the service plan selection options via the service processor 115 user

interface, and service processor 115 communicates the user selection to service controller 122. In some embodiments, service processor 115 communicates a service plan selection via usage record service selection interface 2120. In some embodiments usage record service selection interface 2120 comprises a uniform service plan selection, service plan activation, or service plan purchase information exchange for communication of user service plan selection information between service processor 115 and service controller 122. In some embodiments, the uniform service plan information exchange interface provided to service processor 115 by service controller 122, such as the usage record service selection interface 2120, is consistent across multiple wireless networks so that the service processor 115 service plan selection interface and the device service plan selection user experience are consistent for multiple carrier networks. In this manner, a network element such as service controller 122 can provide a consistent interface across one or multiple networks to enable device agents or device applications to transmit device user service plan selections or service plan purchases to the network elements responsible for provisioning or activating device service plans.

[00144] In some embodiments, service controller 122 communicates the user service plan selection to the network elements responsible for provisioning or activating the service plan (e.g., network provisioning system 160, billing system 123, subscriber management 182, or order management 180) via subscriber onboarding interface 2050. In some embodiments, subscriber onboarding interface 2050 comprises a uniform service plan selection, service plan activation, or service plan purchase information exchange for communication of user service selections between a wireless network element (e.g., network provisioning system 160, billing system 123, subscriber management 182, or order management 180) and service controller 122. In some embodiments, subscriber onboarding interface 2050 comprises a uniform service plan selection, service plan activation, or service plan purchase information exchange for communication of device user service plan selections between a wireless network element and service controller 122 that is consistent across multiple carrier networks. In this way, service controller 122 can provide a uniform translation function that allows an on-device service selection agent (e.g., service processor 115) to interface with the network in a consistent manner to provide a consistent user experience with multiple wireless networks that may have different service plan activation or service plan purchase processes. Another example service selection/provisioning workflow for device-assisted service policy control and an on-device user interface with service plan selection or service plan purchase capability is now described using the embodiment illustrated in Figure 16. A user of end-user device 100 selects one or

more services for purchase using end-user device 100. For example, the user may respond to a service offer presented through a user interface of end-user device 100. Service processor 115 on end-user device 100 sends the service selection to service controller 122. After receiving the service selection via usage record service selection interface 2120, service controller 122 sends a message to the network over service provisioning request interface 2070. Service controller 122 then receives from the network, through service provisioning update interface 2020, an update for the service plan associated with end-user device 100. Based on the update for the service plan, service controller 122 generates a policy set for end-user device 100. Service controller 122 sends the policy set to service processor 115 via policy interface 2110 (or service control device link 1691, service control server link 1638, or another interface). Service processor 115 applies the policy set so that end-user device 100 operates as prescribed by the policy.

[00145] In some embodiments, device identification list interface 2010 allows the network to provide service controller 122 with the device identifications or credentials of end-user devices that are able to participate in device-assisted services, including, for example, end-user devices with service processors, such as end-user device 100. In some embodiments, such end-user devices are identified by service controller 122. In some embodiments, such end-user devices are associated with an appropriate device group before those end-user devices may participate in device-assisted services.

[00146] In some embodiments, device identification list interface 2010 is a batch interface. In some embodiments, data is sent across device identification list interface 2010 using the FTP protocol. In some embodiments, the records sent to service controller 122 via device identification list interface 2010 are fixed-length records. The data elements that may be passed over device identification list interface 2010 include any or all of: IMSI, MSID, MDN, MEID, and device group. As would be appreciated by a person having ordinary skill in the art, other protocols, data formats, and data elements are possible.

[00147] In some embodiments, service provisioning update interface 2020 allows the network to provide service controller 122 with updated service plan selections for an end-user device that supports device-assisted services, such as end-user device 100. In some embodiments, service provisioning update interface 2020 is a single-device interface. In some embodiments, service provisioning update interface 2020 is a device group or user group

multi-device interface. In some embodiments, data is sent across service provisioning update interface 2020 using a web services protocol. In some embodiments, the data sent to service controller 122 via service provisioning update interface 2020 is formatted as XML. The data elements that may be passed over service provisioning update interface 2020 include any or all of: IMSI, MSID, MDN, MEID, service plan selection information (e.g., service plan, charging code, plan start date, plan start time, plan end date, plan end time). As would be appreciated by a person having ordinary skill in the art, other protocols, data formats, and data elements are possible.

[00148] In some embodiments, subscriber onboarding interface 2050 allows service controller 122 to provide the network with device user (or subscriber) credentials or other information, billing information, and/or device user service selection information associated with end-user device 100. In some embodiments, subscriber onboarding interface 2050 is a single-device interface. In some embodiments, subscriber onboarding interface 2050 is a device group or user group multi-device interface. In some embodiments, data is passed over subscriber onboarding interface 2050 using a web services protocol. In some embodiments, the data sent by service controller 122 via subscriber onboarding interface 2050 is formatted as XML. The data elements that may be passed over subscriber onboarding interface 2050 include any or all of: device data (e.g., MEID, IMSI, etc.), subscriber data (e.g., name, address, etc.), billing data (e.g., credit card information, billing address, etc.), selected service plan, charging code, and acceptance of terms and conditions. As would be appreciated by a person having ordinary skill in the art, other protocols, data formats, and data elements are possible.

[00149] In some embodiments, service provisioning request interface 2070 allows service controller 122 to provide the network with subscriber service selection information associated with an end-user device, such as end-user device 100. In some embodiments, service provisioning request interface 2070 is a single-device interface. In some embodiments, data is passed over service provisioning request interface 2070 using a web services protocol. In some embodiments, the data sent by service controller 122 via service provisioning request interface 2070 is formatted as XML. The data elements that may be passed over service provisioning request interface 2070 include any or all of: IMSI, MSID, MDN, MEID, selected service plan, charging code, and acceptance of terms and conditions. As would be appreciated by a person having ordinary skill in the art, other protocols, data formats, and data elements are possible.

[00150] Uniform Interfaces for Classification of Service Usage

[00151] Network usage report interface 2030 comprises a uniform information exchange interface for communication of end-user device 100 service usage information to service controller 122. In some embodiments, end-user device 100 service usage information is gathered in the network and communicated to service controller 122. In some embodiments, service usage information is communicated from service controller 122 to end-user device 100 via a uniform service usage information exchange interface (e.g., policy interface 2110, service control device link 1691, service control server link 1638, or another interface) so that end-user device agents or applications (such as a service processor 115) can be configured to receive service usage information from a uniform interface. In some embodiments, service usage information is communicated from service controller 122 to end-user device 100 via a uniform service usage information exchange interface (e.g., policy interface 2110, service control device link 1691, service control server link 1638, or another interface) that is consistent across multiple wireless networks. In some embodiments, network usage report interface 2030 is a single-device interface. In some embodiments, service provisioning update interface 2020 is a device group or user group multi-device interface. In some embodiments, service usage information is passed over network usage report interface 2030 using a web services protocol. In some embodiments, the data sent to service controller 122 via network usage report interface 2030 is formatted as XML.

[00152] In some embodiments, network usage report interface 2030 (or FDR report interface 2040) can comprise a uniform network service usage information exchange that includes a classification of service usage. In some embodiments, the classification of service usage can include classification of data network usage by one or more of device application, network destination, network service type, network service class, network traffic type, network QoS class, device type, network type, time of day, network congestion level, or home or roaming network service usage. In some embodiments, the service usage information that is communicated to service controller 122 comprises one or more classifications of service usage. In some embodiments, the service usage information that is communicated via a uniform service usage information exchange interface (e.g., policy interface 2110, service control device link 1691, service control server link 1638, or another interface) to service processor 115 comprises one or more classifications of service usage. The data elements that may be passed over network usage report interface 2030 include any or all of: IMSI, MSID, MDN,

MEID, usage report start time, usage report end time, number of bytes sent by the end-user device, number of bytes sent to the end-user device, service plan, charging code, percentage of plan used. As would be appreciated by a person having ordinary skill in the art, other protocols, data formats, and data elements are possible.

[00153] In some embodiments, CDR interface 2060 allows service controller 122 to provide the network with detailed device usage information, such as for end-user device 100. In some embodiments, CDR interface 2060 is a single-device interface. In some embodiments, data is passed over CDR interface 2060 using a web services protocol. In some embodiments, the data sent by service controller 122 via CDR interface 2060 is formatted as XML. The data elements that may be passed over CDR interface 2060 include any or all of: MEID, IMSI, MSID, MDN, start time, end time, usage data (e.g., service plan, charging code, number of bytes sent by the end-user device, number of bytes received by the end-user device). As would be appreciated by a person having ordinary skill in the art, other protocols, data formats, and data elements are possible.

[00154] In some embodiments, FDR report interface 2040 allows the network to provide service controller 122 with detailed data usage information for an end-user device, such as end-user device 100. In some embodiments, the report is based on a prior FDR report request initiated by service controller 122. In some embodiments, FDR report interface 2040 is a single-device interface. In some embodiments, data is passed over FDR report interface 2040 using a web services protocol. In some embodiments, the data sent to service controller 122 via FDR report interface 2040 is formatted as XML. The data elements that may be passed over FDR report interface 2040 include any or all of: IMSI, MSID, MDN, MEID, usage report start time, usage report end time, usage data (e.g., remote IP address, remote port, number of bytes sent by the end-user device, number of bytes sent to the end-user device). As would be appreciated by a person having ordinary skill in the art, other protocols, data formats, and data elements are possible.

[00155] In some embodiments, FDR request interface 2080 allows the service controller to request FDRs for a specific end-user device, such as end-user device 100, for a specific period of time. In some embodiments, FDR request interface 2080 is a single-device interface. In some embodiments, data is passed over FDR request interface 2080 using a web services protocol. In some embodiments, the data sent by service controller 122 via FDR request

interface 2080 is formatted as XML. The data elements that may be passed over FDR request interface 2080 include any or all of: IMSI, MSID, MDN, MEID, start time, end time. As would be appreciated by a person having ordinary skill in the art, other protocols, data formats, and data elements are possible.

[00156] Service Usage Anomaly Detection

[00157] An exemplary embodiment illustrating the detection of service usage anomalies in device-generated usage data records using carrier-based usage data records is now described with reference to Figure 16.

[00158] Service processor 115 on end-user device 100 sends device-generated (also referred to as “device-based”) usage data reports (UDRs) to service controller 122 via the access network. The UDRs contain information about the data usage of end-user device 100. For example, the UDRs may indicate how many bytes of data associated with a particular application, such as a map application, or service, such as a music streaming service, end-user device 100 consumed since the last report, or during a particular time period. For example, a UDR may contain some or all of the following information: subscriber identification (e.g., IMSI, MSID, NAI, MDN), equipment identification (e.g., IMEI or MEID), start time, stop time, domain name, remote IP address, remote port, application, control policy identification, charging policy identification, filter identification, network busy state, information about the active network (e.g., whether it is 2G, 3G, 4G, or WiFi), access point name (APN), access point type, classification type (e.g., whether direct or associative), number of bytes sent by end-user device 100, number of bytes received by end-user device 100. As would be appreciated by a person having ordinary skill in the art, a UDR may contain other information associated with end-user device 100. In some embodiments, end-user device 100 sends the UDRs periodically. In some embodiments, end-user device 100 sends the UDRs in response to one or more requests from service controller 122.

[00159] In addition to receiving UDRs from end-user device 100, service controller 122 also receives carrier-based device usage reports from the carrier usage reporting system. In some embodiments, these carrier-based reports are received via usage report interface 2030. The carrier-based usage reports contain information about data usage by end-user device 100, as determined by the network. For example, a carrier usage record, which may be, for example, a charging data record (CDR), may contain some or all of the following information:

subscriber identification (e.g., IMSI, MSID, NAI, or MDN), equipment identification (e.g., IMEI or MEID), correlation identification, start time, stop time, number of bytes sent by end-user device 100, number of bytes received by end-user device 100, access point name (APN). As would be appreciated by a person having ordinary skill in the art, a carrier-based device usage report may contain other information associated with end-user device 100.

[00160] In some embodiments, service controller 122 compares information in UDRs sent by service processor 115 to carrier-based usage reports received from the network to determine whether end-user device 100 is likely operating in compliance with an established policy, or whether end-user device 100 is likely operating in a fraudulent manner.

[00161] The carrier-based usage report may specify a time period associated with the data included in the report. In some embodiments in which the carrier-based usage report specifies a time period associated with the data included in the report, for the time period specified in the carrier-based usage report, service controller 122 compares information in the received UDRs to constraints in effect during the specified time period. Such constraints may include, for example, policy limits, usage metrics, or other measures associated with the use of data by end-user device 100. In some embodiments, for the time period specified in the carrier-based usage report, service controller 122 compares aggregated usage counts in the carrier-based usage report to an aggregated usage count determined based on one or more UDRs received from service processor 115.

[00162] In some embodiments, service controller 122 reconciles time period differences between information received from service processor 115 and network sources of service usage information. In some embodiments, time period reconciliation is accomplished by aggregating a number of measurement time periods until the percentage difference in time periods is small. In some embodiments, time period reconciliation is accomplished by aggregating a first number of device-based usage reports and a second number of network-based usage reports. In some embodiments, time period reconciliation is accomplished by maintaining a running average or running accumulation of service usage from each source.

[00163] In some embodiments, if service controller 122 detects possible fraudulent activity by end-user device 100, service controller 122 requests flow data record (FDR) data from the network for the time period specified in the carrier-based usage report and performs

additional analysis based on the FDR data. In some embodiments, service controller 122 requests the FDR data via FDR request interface 2080.

[00164] In some embodiments, based on its analysis of the UDRs and carrier-based data records, which may include FDR data, service controller 122 sets an indicator or flag to indicate potential fraudulent activity. The indicator or flag is specific to end-user device 100 and, in some embodiments in which the carrier-based usage reports specify a time period, the time period specified by the carrier-based usage report.

[00165] In some embodiments, the indicator or flag is communicated to the network using fraud alert interface 2090. In some embodiments, fraud alert interface 2090 allows service controller to notify the network of potential fraud detection associated with an end-user device, such as end-user device 100. In some embodiments, fraud alert interface 2090 is a single-device interface. In some embodiments, data is passed over fraud alert interface 2090 using a web services protocol. In some embodiments, the data sent by service controller 122 via fraud alert interface 2090 is formatted as XML. The data elements that may be passed over fraud alert interface 2090 include any or all of: IMSI, MSID, MDN, MEID, fraud alert start time, fraud alert end time, affected service plan, affected charging code, fraud reason code (e.g., no device report, count mismatch, etc.). As would be appreciated by a person having ordinary skill in the art, other protocols, data formats, and data elements are possible.

[00166] In some embodiments, after service controller 122 has completed the anomaly detection procedure, if the potential fraud indicator or flag is not set, service controller 122 generates charging data records with detailed charging codes for the data usage by end-user device 100. In some embodiments in which the carrier-based usage reports specify a time period, the charging data records are for the time period specified in the carrier-based usage record. In some embodiments, service controller 122 sends the charging data records to the service provider over CDR interface 2060.

[00167] In some embodiments, if the potential fraud indicator or flag is set, service controller 122 waits for the network to send an FDR report via FDR report interface 2040 for end-user device 100. When service controller 122 receives the FDR report, service controller 122 performs validation of the carrier-based usage report based on the FDR report. If the counts do not agree, service controller 122 sends a fraud alert message over fraud alert interface 2090. If the counts agree, service controller 122 generates charging data records with

detailed charging codes for data usage by end-user device 100 during the time period specified in the carrier-based usage record. In some embodiments, service controller 122 sends the charging data records to the service provider over CDR interface 2060.

[00168] Uniform Customer Acknowledgment Interface

[00169] In some embodiments, customer acknowledgment interface 2100 allows service controller 122 to notify the network of an end user's selecting of "Acknowledge" in response to an end-user device notification that has an "Acknowledge" option. In some embodiments, customer acknowledgment interface 2100 is a single-device interface. In some embodiments, data is passed over customer acknowledgment interface 2100 using a web services protocol. In some embodiments, the data sent by service controller 122 via customer acknowledgment interface 2100 is formatted as XML. The data elements that may be passed over customer acknowledgment interface 2100 include any or all of: IMSI, MSID, MDN, MEID, acknowledge time, acknowledge event (e.g., allow an overage), acknowledge service plan (e.g., 50 MB browsing plan), acknowledge charging code. As would be appreciated by a person having ordinary skill in the art, other protocols, data formats, and data elements are possible.

[00170] Although the foregoing embodiments have been described in some detail for purposes of clarity of understanding, the invention is not limited to the details provided. There are many alternative ways of implementing the invention. The disclosed embodiments are illustrative and not restrictive.

CLAIMS:

WHAT IS CLAIMED IS:

1. A mobile end-user device comprising:
a wireless local area network (WLAN) modem to communicate data for Internet service activities between the device and selected WLAN access points, when configured for connection to, and connected to, a selected WLAN access point allowing such data communication;
a modem selection and control function configured to
select a current available WLAN access point reachable through the WLAN modem, and
connect the WLAN modem to the current available WLAN access point in an ambient access mode, the ambient access mode supporting automated device provisioning of secure service plan credentials and not supporting network access for general Internet service activities; and
one or more service processor agents configured to
request, from a wireless network service selection information exchange reachable via the current available WLAN access point in the ambient access mode, service selection information identifying service providers issuing service plan credentials that are accepted by an operator of the WLAN access point to authorize general Internet service activity network access through the WLAN access point,
receive, from the wireless network service selection information exchange in response to the request, service plan selection options for a plurality of service providers, including one or more service providers other than the WLAN access point operator,
automatically select at least one secure service plan credential stored on the device, the at least one secure service plan credential provisioned for use with a service provider selected from the selection options, the selected service provider not the WLAN access point operator, and
automatically supply, to a server granting access authorization to wireless devices for use of the WLAN access point for general Internet service activity network access, the selected at least one secure service plan credential, thereby

allowing the modem selection and control function to connect the WLAN modem to the WLAN access point in a mode that allows general Internet service activity network access.

2. The mobile end-user device of claim 1, further comprising a wireless wide area network (WWAN) modem to communicate data for Internet service activities between the device and at least one WWAN access network, when connected to the at least one WWAN access network, the device accessing the WWAN access network using the selected at least one secure service plan credential.
3. The mobile end user device of claim 2, wherein the selected at least one secure service plan credential comprises a Mobile Equipment Identifier (MEID).
4. The mobile end-user device of claim 1, wherein the selected at least one secure service plan credential comprises a Mobile Equipment Identifier (MEID).
5. The mobile end-user device of any one of claims 1-4, wherein the selected at least one secure service plan credential comprises a programmable embedded device descriptor information block.
6. The mobile end-user device of any one of claims 1-5, the device storing the at least one secure service plan credential on a Subscriber Information Module inserted in the device.
7. The mobile end-user device of any one of claims 1-4, wherein the selected at least one secure service plan credential comprises at least one of a hardware secure device identifier, a secure signature, a security signature algorithm, and secure authorization information.
8. The mobile end-user device of any one of claims 1-4, wherein the selected at least one secure service plan credential comprises a token.
9. The mobile end-user device of any one of claims 1-8, wherein the one or more service

processor agents are further configured to receive the selected at least one secure service plan credential through the ambient access mode connection point, and automatically provision the device with the received credential.

10. The mobile end-user device of claim 9, wherein the one or more service processor agents are further configured to automatically associate the received credential with a correct activation action to be taken on the device.

11. The mobile end-user device of claim 9, wherein the one or more service processor agents are further configured to automatically associate the received credential with an activation function sequence to be taken with a network connection attempt using the received credential.

12. The mobile end-user device of any one of claims 1-11, further comprising a user interface, wherein the one or more service processor agents comprise an on-device service selection agent, the on-device service selection agent to display the service plan selection options on the user interface to a device user, and to register a user selection from among the displayed options as the selected service provider.

13. The mobile end-user device of claim 12, the on-device service selection agent further to, while the device is connected to the current available WLAN access point in the ambient access mode, communicate through the WLAN access point with a service plan provisioning and activation system associated with the selected service provider to assist the user in subscribing with the selected service provider.

14. The mobile end-user device of claim 13, the one or more service processor agents further configured to, after the user has subscribed with the selected service provider and while the device is connected to the current available WLAN access point in the ambient access mode, automatically receive at least one secure service plan credential from the service plan provisioning and activation system, and automatically securely provision that credential on the device.

15. The mobile end-user device of claim 14, the one or more service processor agents further configured to, upon automatically securely provisioning that credential on the device, initiate the automatic select and automatic supply of that credential to the server granting access authorization.

16. The mobile end-user device of any one of claims 1-15, the secure service plan credentials stored on the device including secure service plan credentials provisioned for a second WLAN access point operator, such that, upon the modem selection and control function selecting as the current available WLAN access point a WLAN access point operated by the second WLAN access point operator, the one or more service processor agents to automatically select the stored credentials provisioned for the current available WLAN access point operator instead of the credentials provisioned for a service provider that is not the WLAN access point operator.

17. The mobile end-user device of any one of claims 1-16, further comprising a multimode profile memory configured to store a plurality of service profiles applicable to corresponding wireless network connections, each service profile including one or more network policy settings applicable to that service profile, the one or more service processor agents further configured to:

- select a service profile from the multimode profiles, based on the selected service provider; and

- while the device is connected to the WLAN access point in the mode that allows general Internet service activity network access, apply the selected service profile to limit network traffic for one or more Internet service activities attempting access to the Internet through the WLAN access point.

18. The mobile end-user device of claim 17, wherein apply the selected service profile to limit traffic for one or more Internet service activities comprises disallowing traffic based on an association of the traffic with at least one application that is executable on the device, but not disallowing traffic associated with all applications executable on the device to generate Internet traffic.

19. The mobile end-user device of claim 17, wherein apply the selected service profile to limit traffic for one or more Internet service activities comprises disallowing traffic based on the traffic being of at least one traffic content type, but not disallowing traffic of all traffic content types used by the mobile end-user device.

20. The mobile end-user device of claim 17, wherein apply the selected service profile to limit traffic for one or more Internet service activities comprises disallowing traffic based on an association of the traffic with at least one network communication end point reachable through the WLAN access point, but not disallowing traffic associated with all network communication endpoints reachable through the WLAN access point.

Figure 1

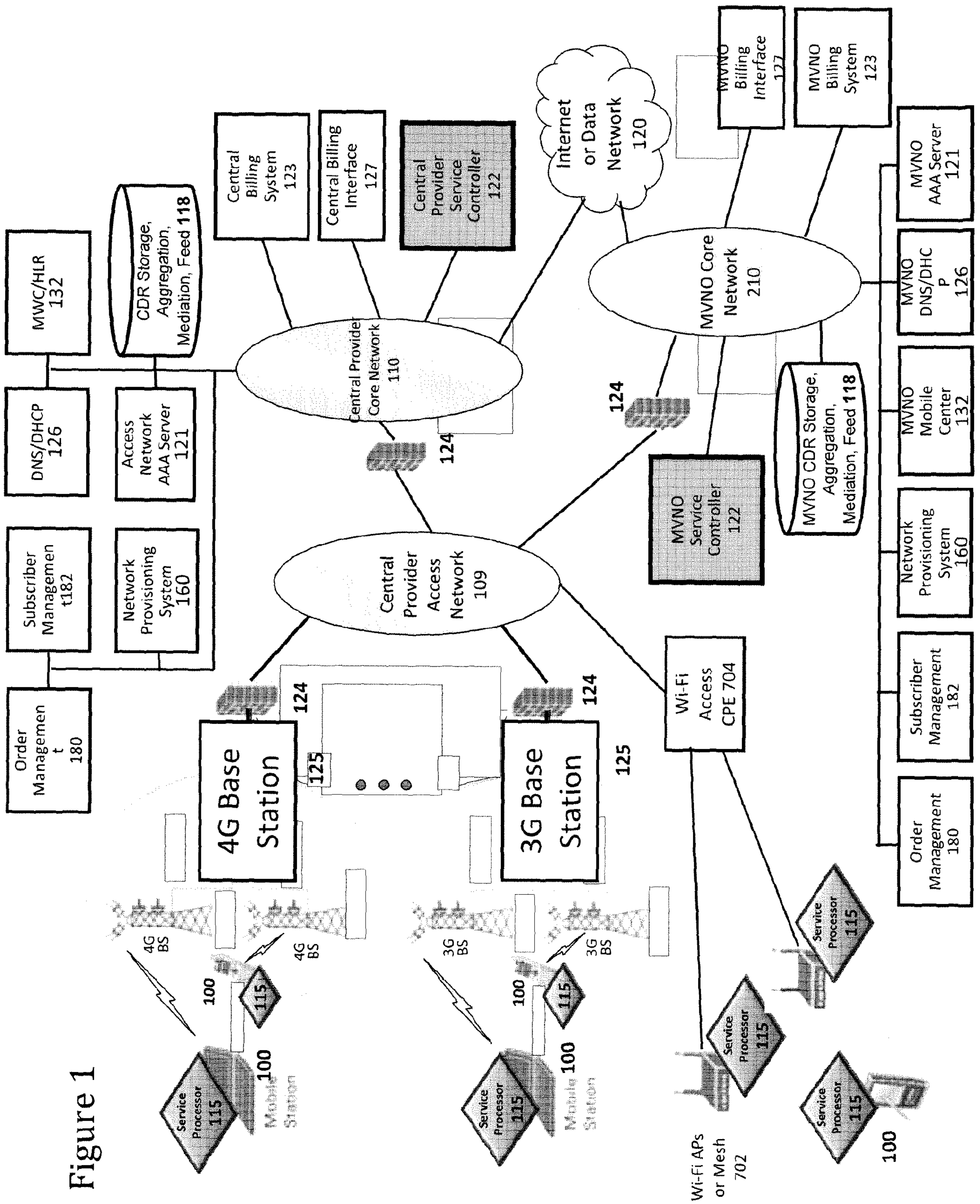
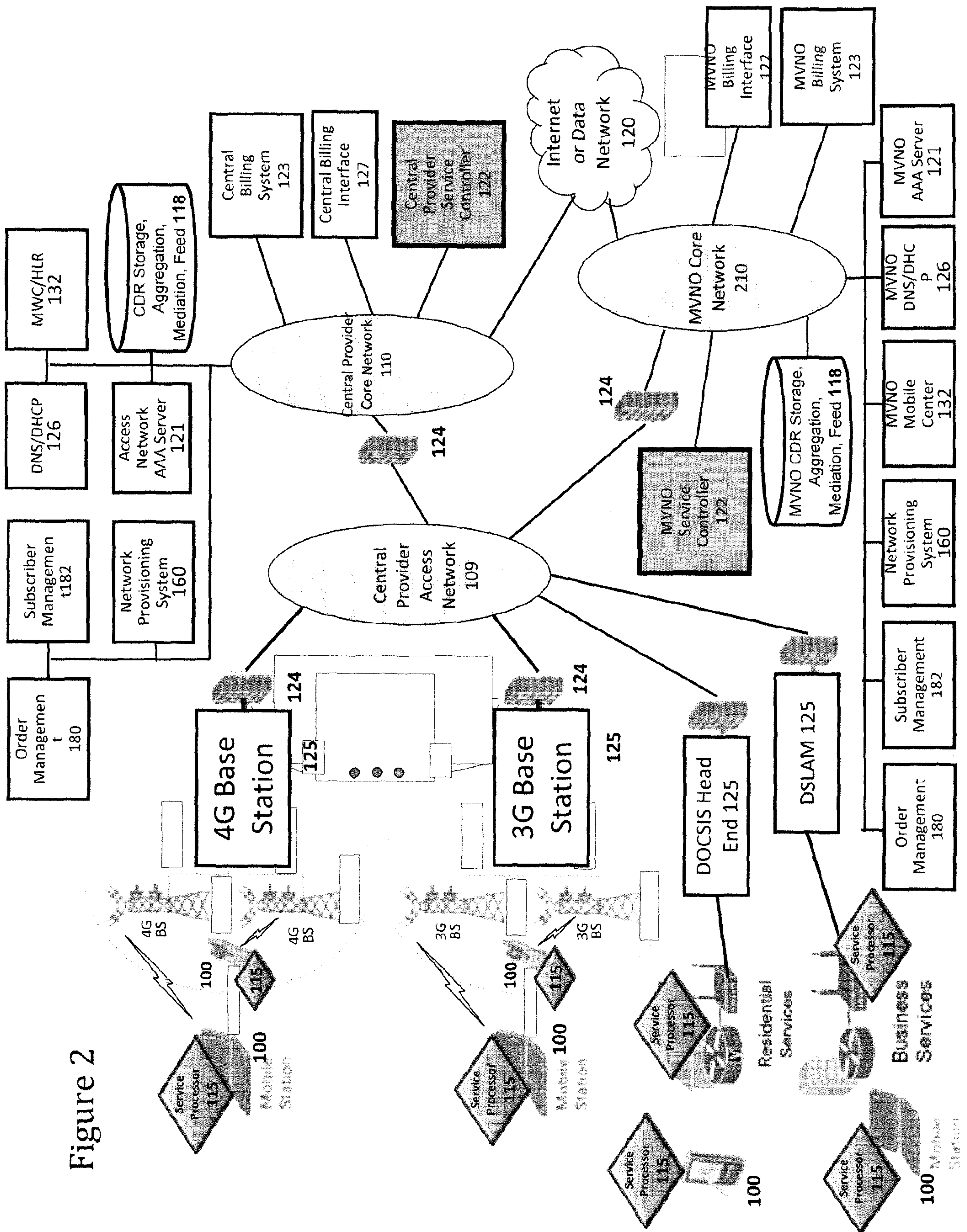


Figure 2



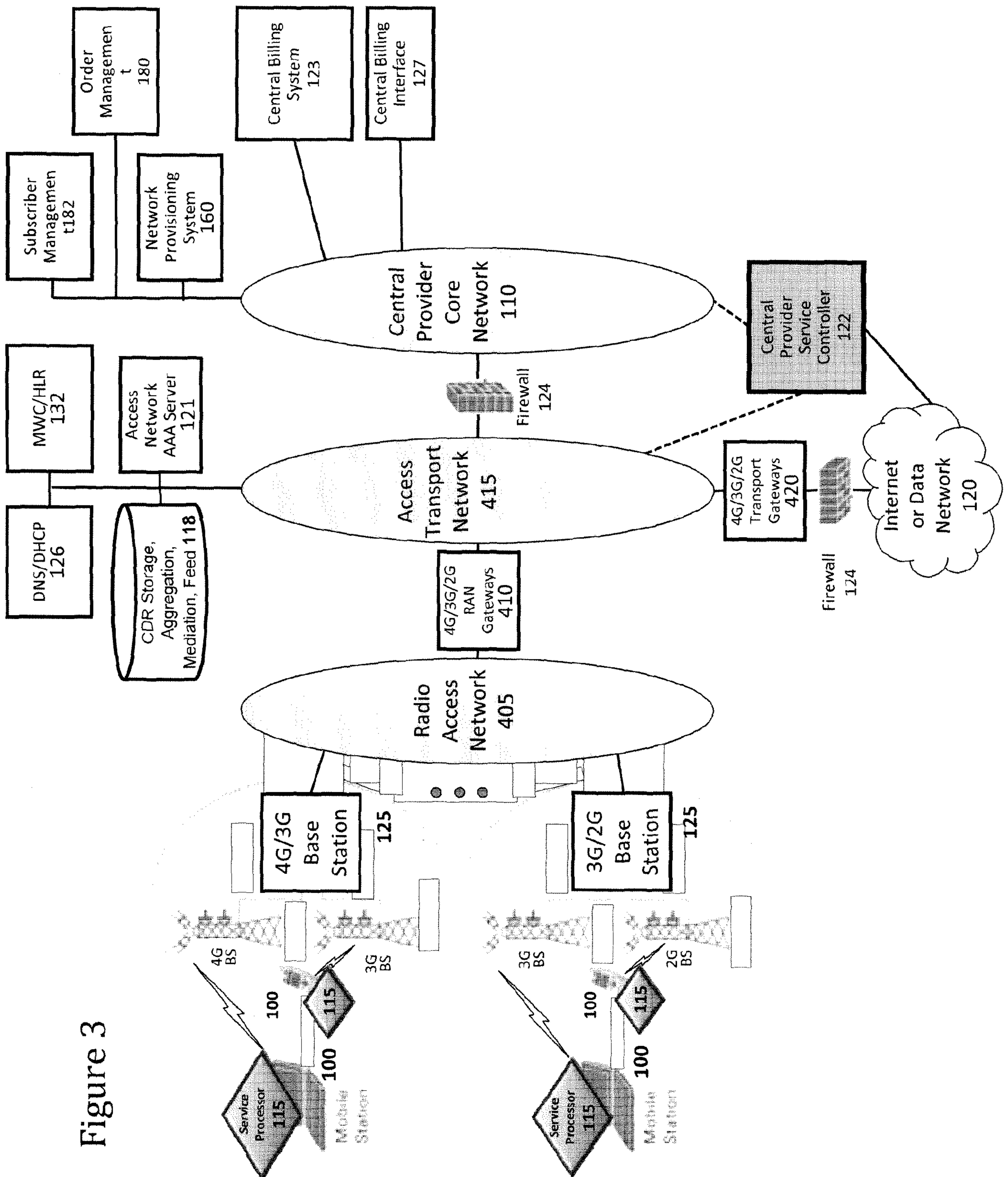


Figure 4

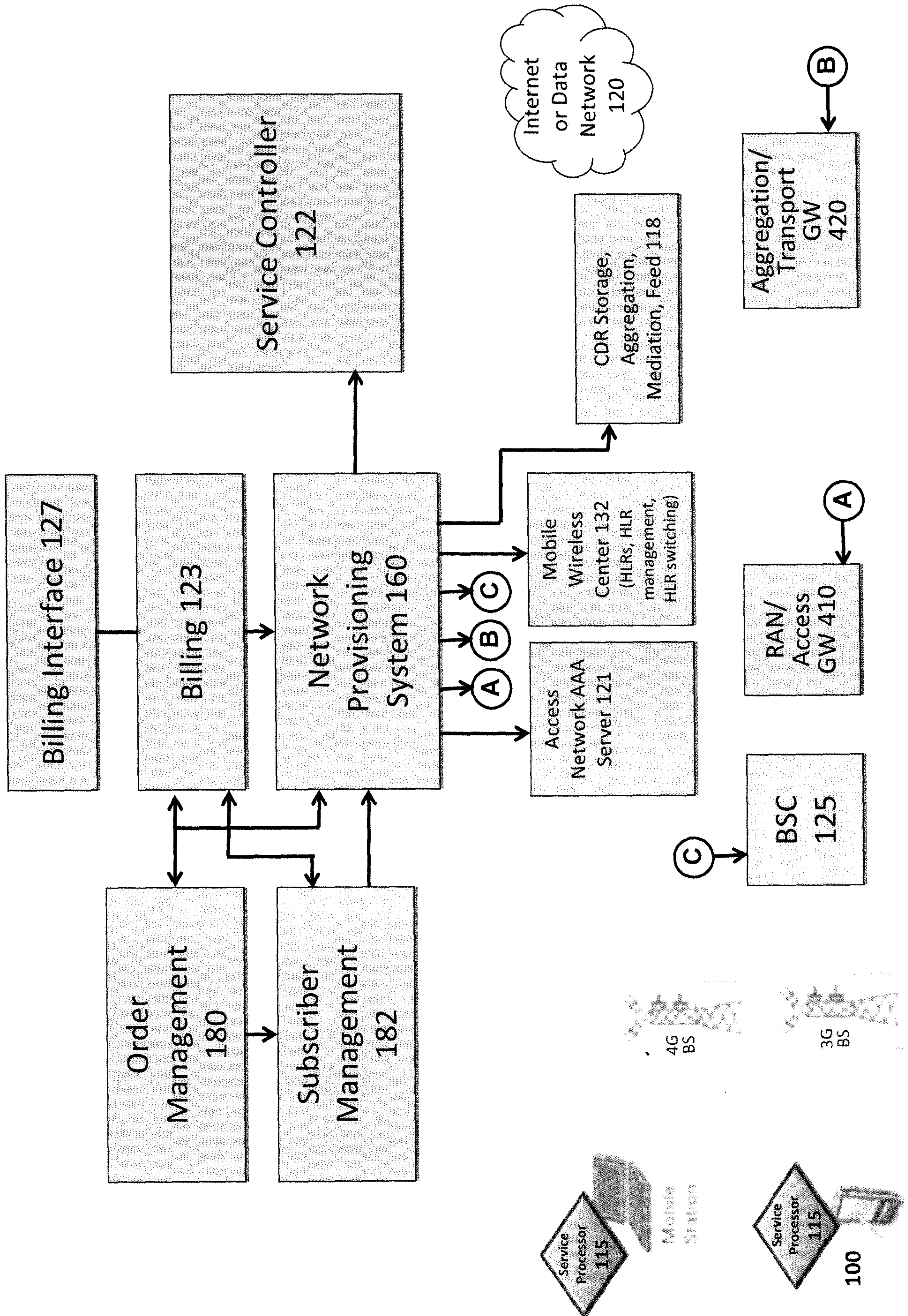


Figure 5

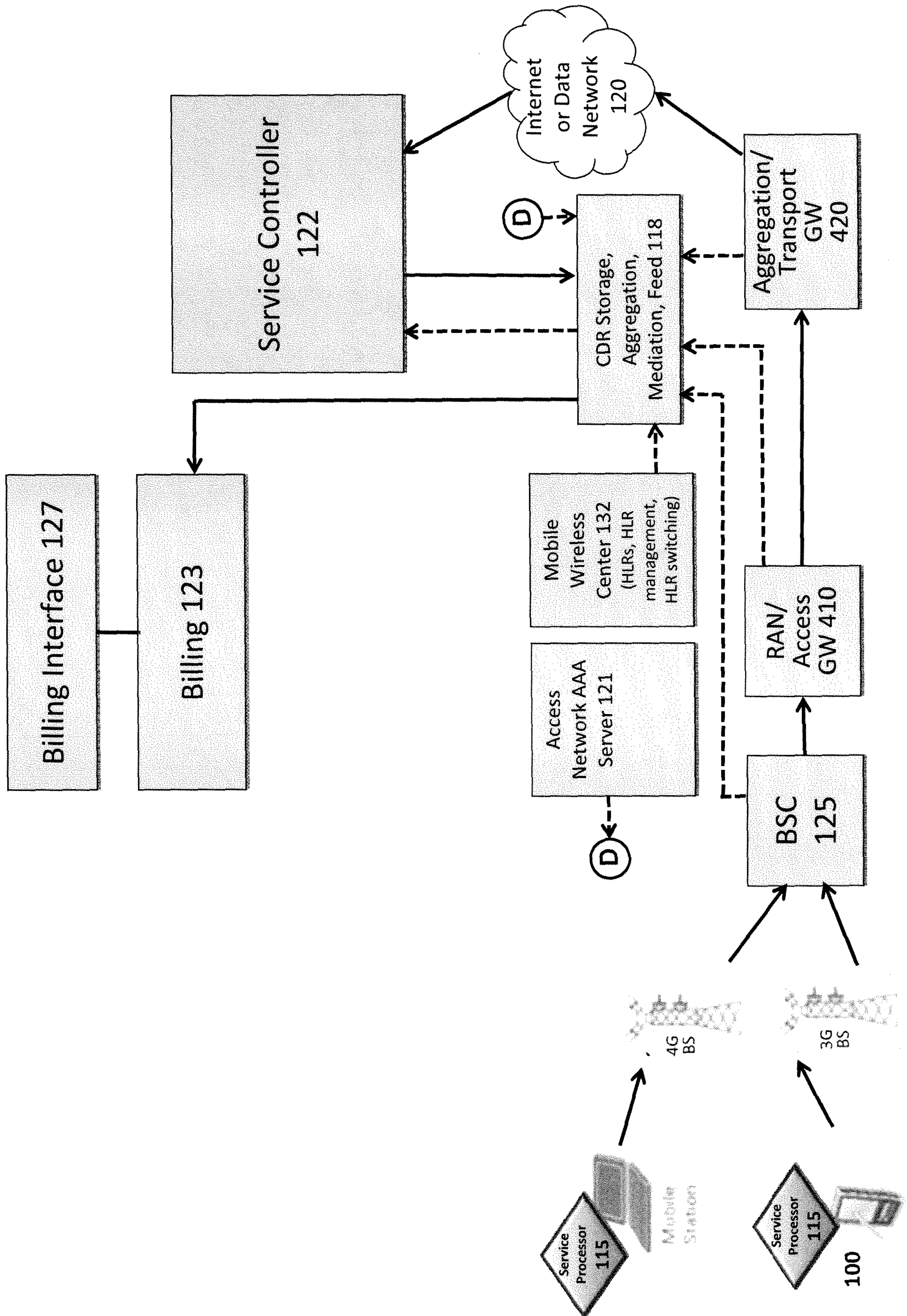


Figure 6

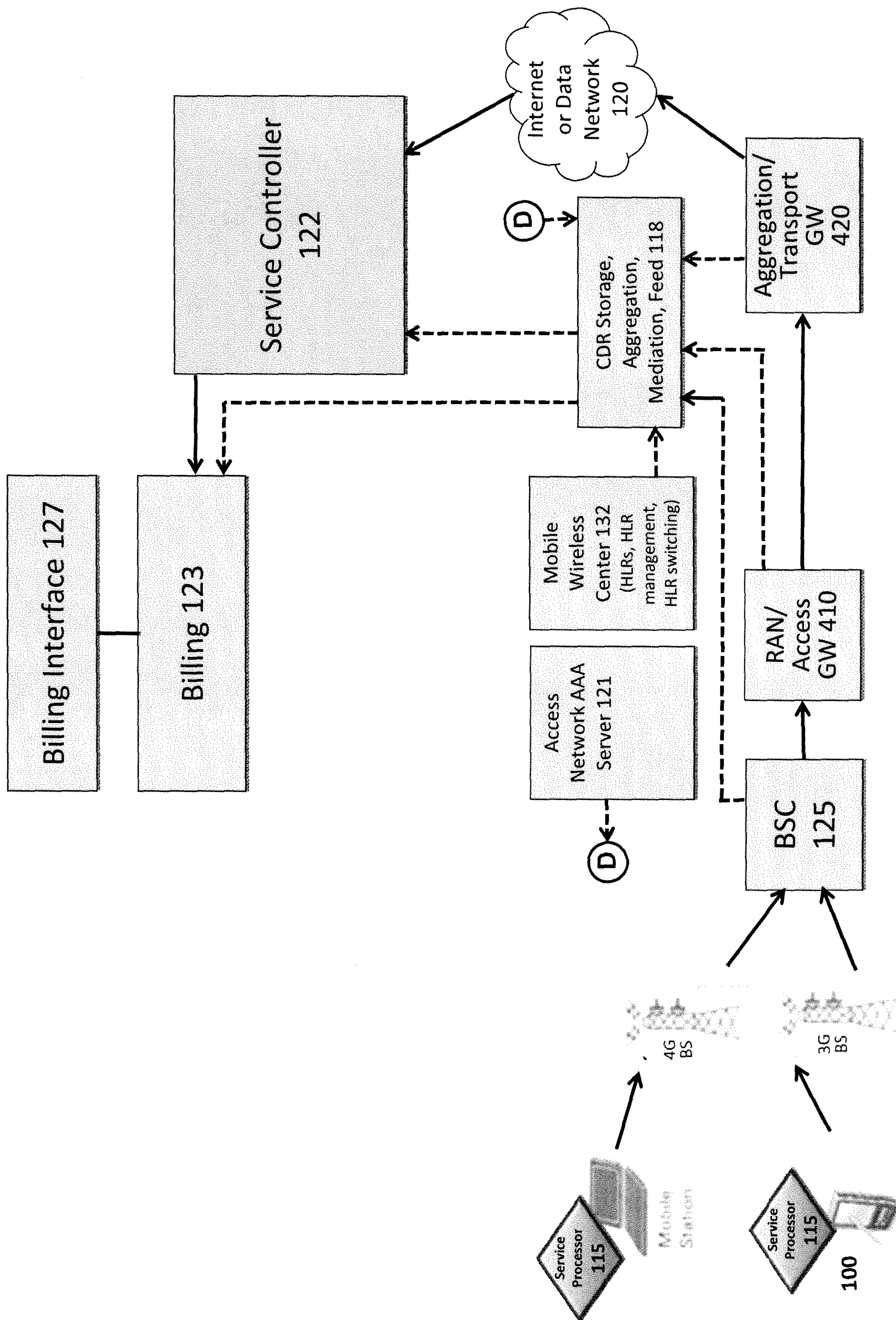


Figure 7

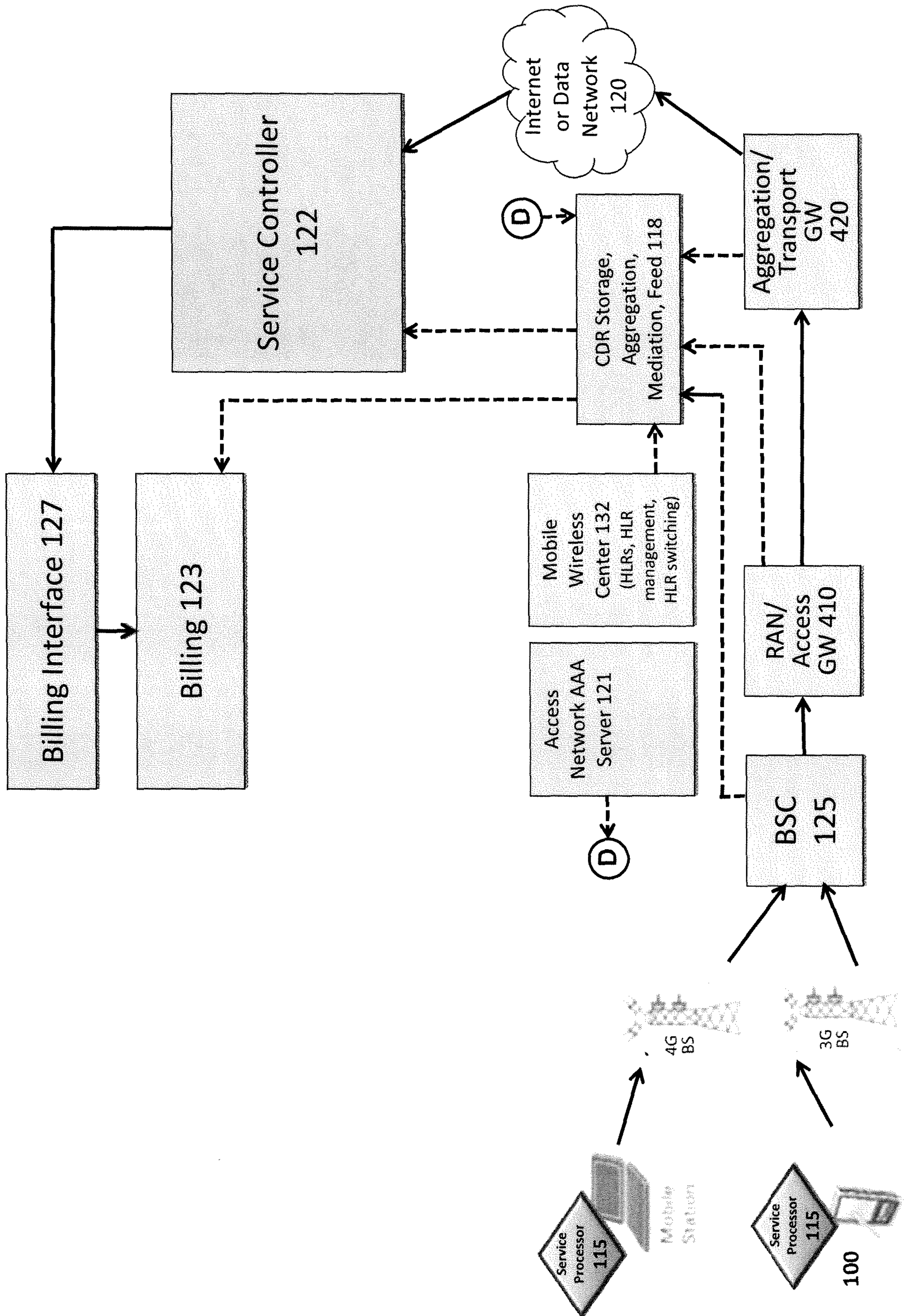
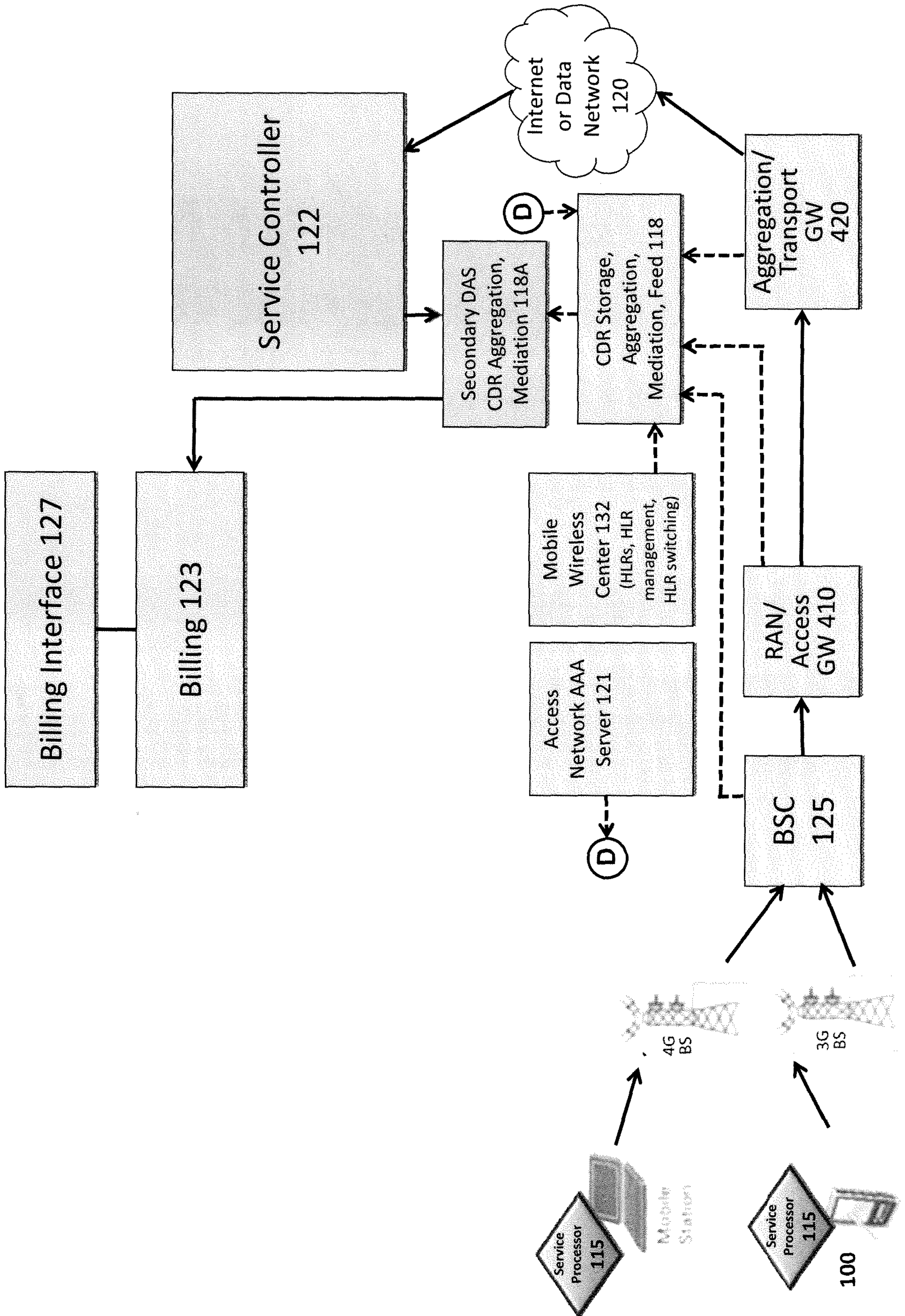


Figure 8



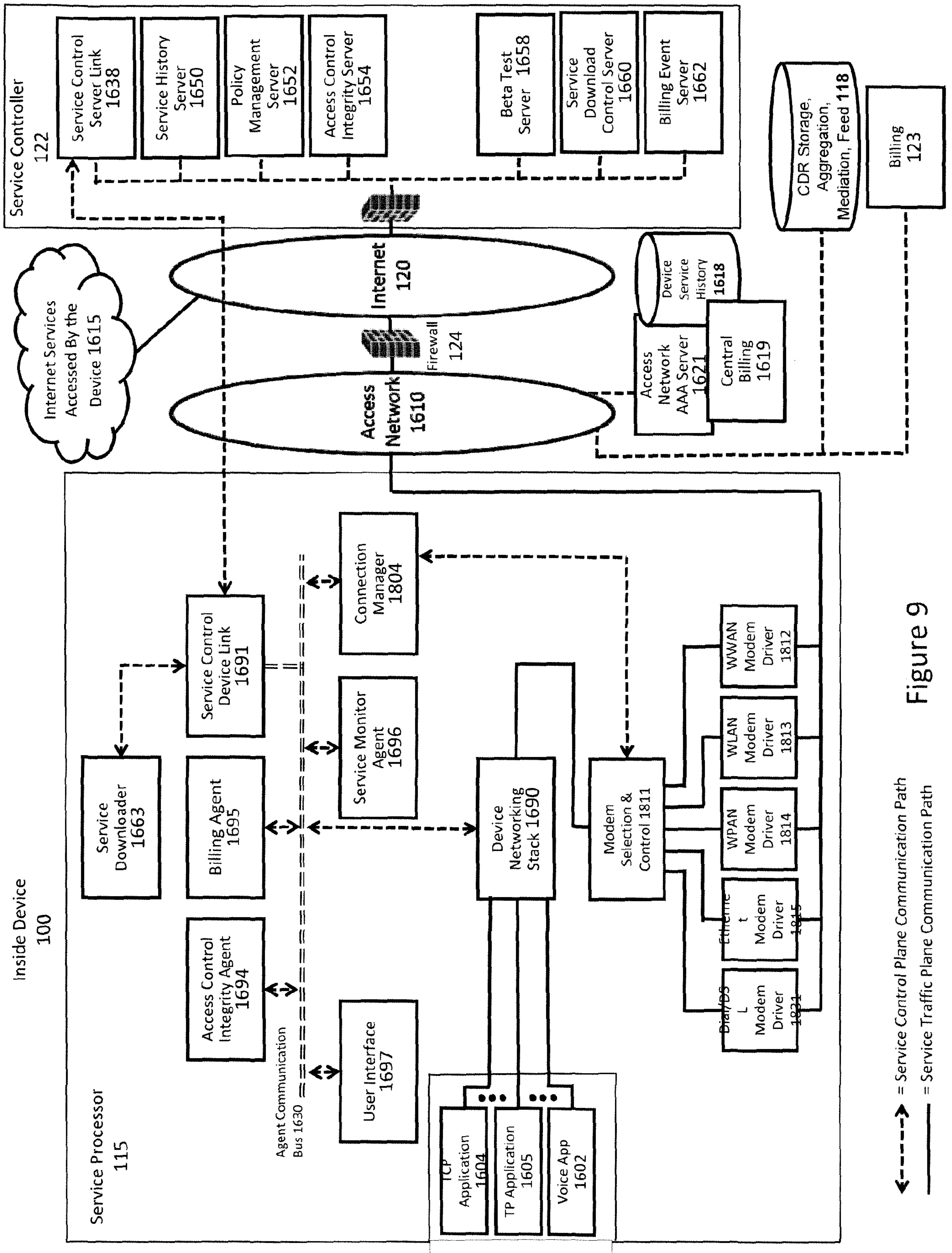


Figure 9

Service Processor 115 Embodiment	Partial Summary of Embodiment Functions
Service Control Device Link 1691	Device side control plane link for connecting Service Processor 415 to Service Controller. In some embodiments, also serves as the link for the agent heartbeat function.
Access Control Integrity Agent 1694	Collects device information on service policy, service usage, agent configuration and agent behavior. Cross checks this information to identify integrity breaches in the service policy implementation and control system. Initiates action when a service policy violation or a system integrity breach is suspected. In some embodiments, verifies configuration of other agents or performs challenge-response sequence testing. In some embodiments, monitors software loading activity, protected memory access or communication with Service Processor agents to detect unauthorized changes to Service Processor software or configuration.
Service Monitor Agent 1696	Records and reports device service usage. In some embodiments, assists in communicating application tagging of traffic flows through the networking stack policy implementation. In some embodiments, maintains a history and provides reports or summary reports of which networks in addition to the networks controlled by the Service Controller that the device has connected to. In some embodiments, this network activity summary may include a summary of the networks accessed, activity vs. time per connection, traffic vs. time per connection.
Billing Agent 1695	Detects and reports billing events. In some embodiments interacts with the User Interface Agent 497 to provide the user with service plan options, accept service plan selections, provide notification on service usage levels, provide options on service usage control policy, accept choices on service usage policy, provide transaction options or accept transaction choices. In some embodiments, interacts with Transaction Servers 134 to conduct ecommerce transactions with central billing.
User Interface 1697	Provide service interface to users.
Service Downloader 1663	Provides a download function to install or update service software elements on the device.
Connection Manager 1804	Provides a control and supervision function for one or more modem drivers or modems that connect to an access network.
Modem Selection and Control 1811	Selects the access network connection.
Modem Drivers 1831, 1815, 1814, 1813, 1812	Converts data traffic into modem bus traffic for one or more modems.
Modems 2141, 2125, 2124, 2123, 2122	Connects the device to one or more networks.

Figure 10

Service Controller 122 Element	Partial Summary of Embodiment Functions
Service Control Server Link 1638	Network side control plane link for connecting Service Controller 122 and Service Processor 115 device agents. In some embodiments, also serves as the link for the agent heartbeat function.
Access Control Integrity Server 1654	Collects device information on service policy, service usage, agent configuration and agent behavior. Cross checks this information to identify integrity breaches in the service policy implementation and control system. Initiates action when a service policy violation or a system integrity breach is suspected.
Service History Server 1650	Collects and records service usage reports from the Access Network AAA Server 1621 and the Service Monitor Agent 1696. In some embodiments, maintains a history of which networks in addition to the networks controlled by the Service Controller that the device has connected to. In some embodiments, this network activity summary may include a summary of the networks accessed, activity vs. time per connection, traffic vs. time per connection. In some embodiments, this activity summary is further analyzed or reported to estimate the type of service plan associated with the traffic activity for the purpose of bill sharing reconciliation.
Central Provider Billing System 123	Provides mediation function for central provider billing events. Accepts service plan changes. In some embodiments, provides updates on device service usage, service plan limits or service policies.
Billing Event Server 1662	In some embodiments, collects billing events, provides service plan information to the Service Processor 115, provides service usage updates to the Service Processor 115, serves as interface between device and central Provider Billing System 123, or provides trusted third party function for certain ecommerce billing transactions.
Service Download Control Server 1660	Provides a download function to install or update service software elements on the device.

Figure 11

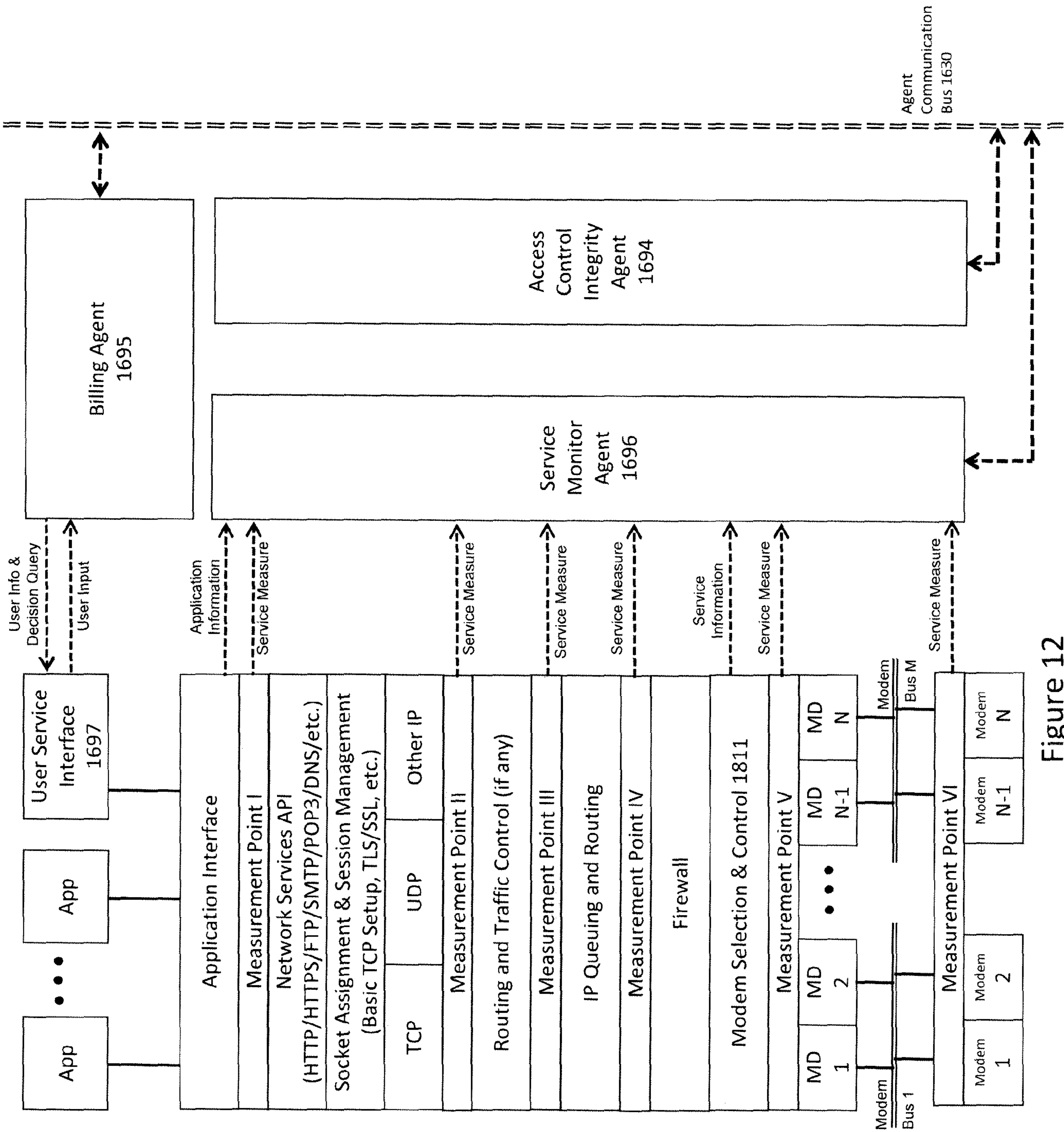


Figure 12

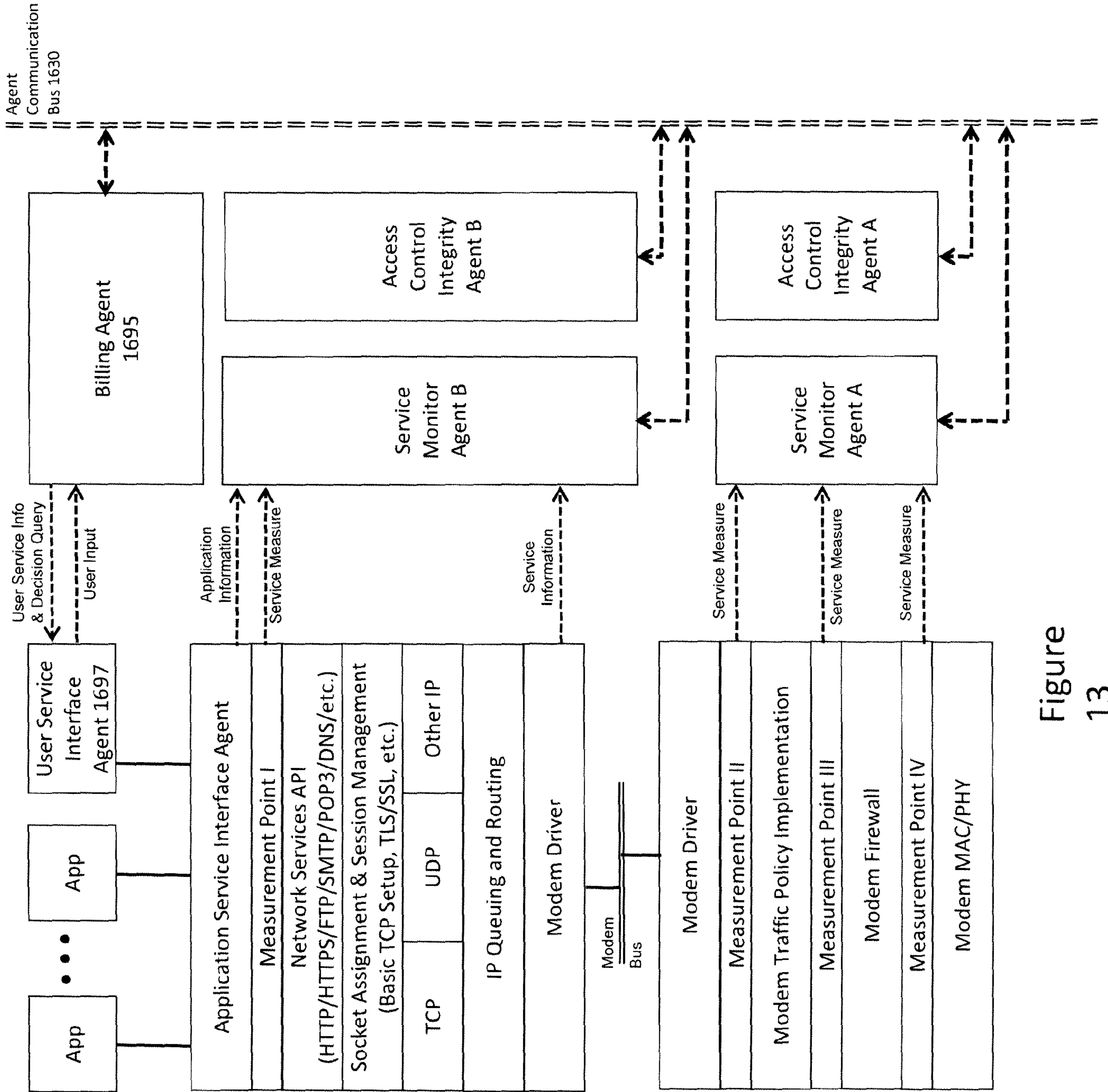


Figure 13

Figure 14(A)

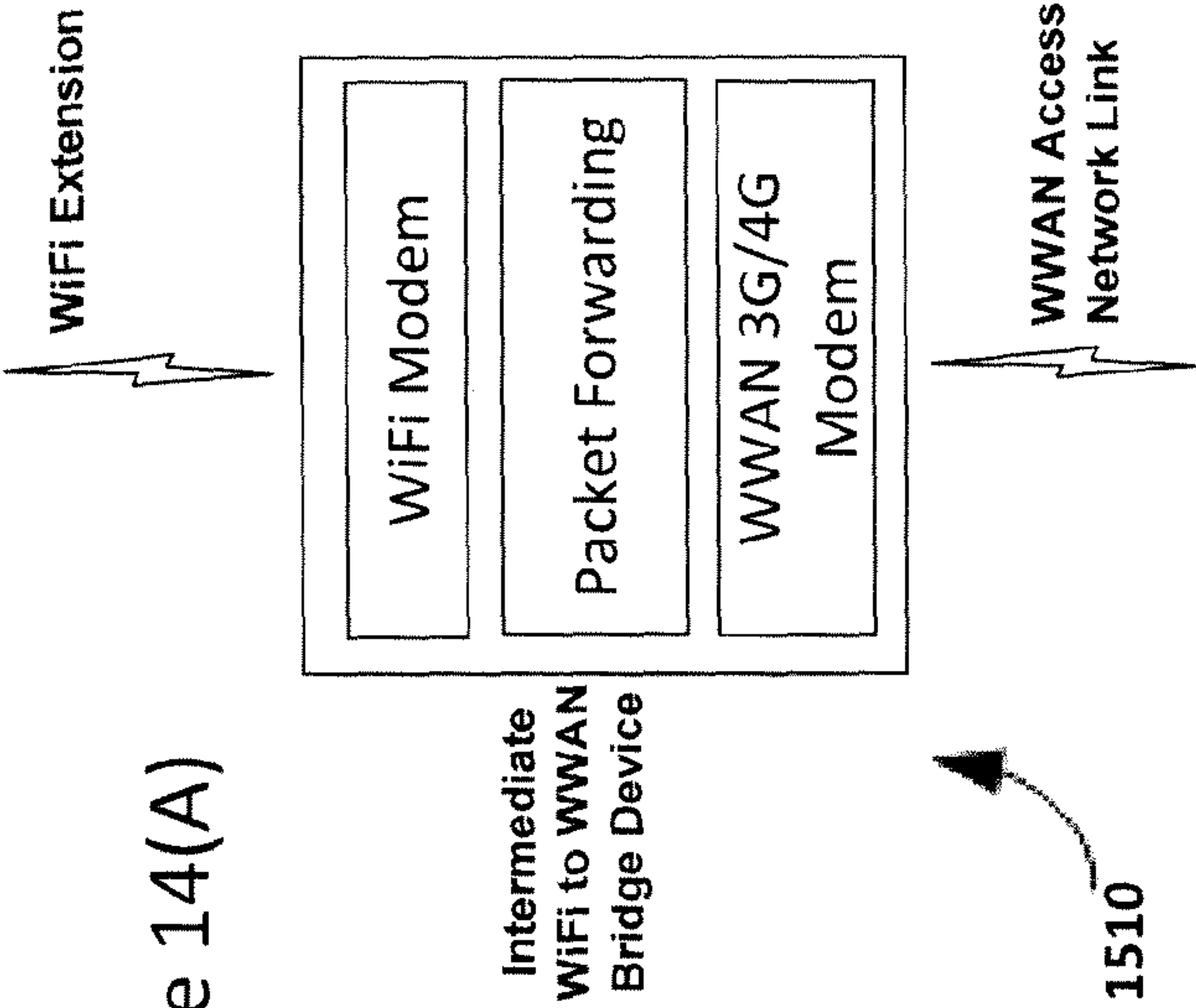


Figure 14(B)

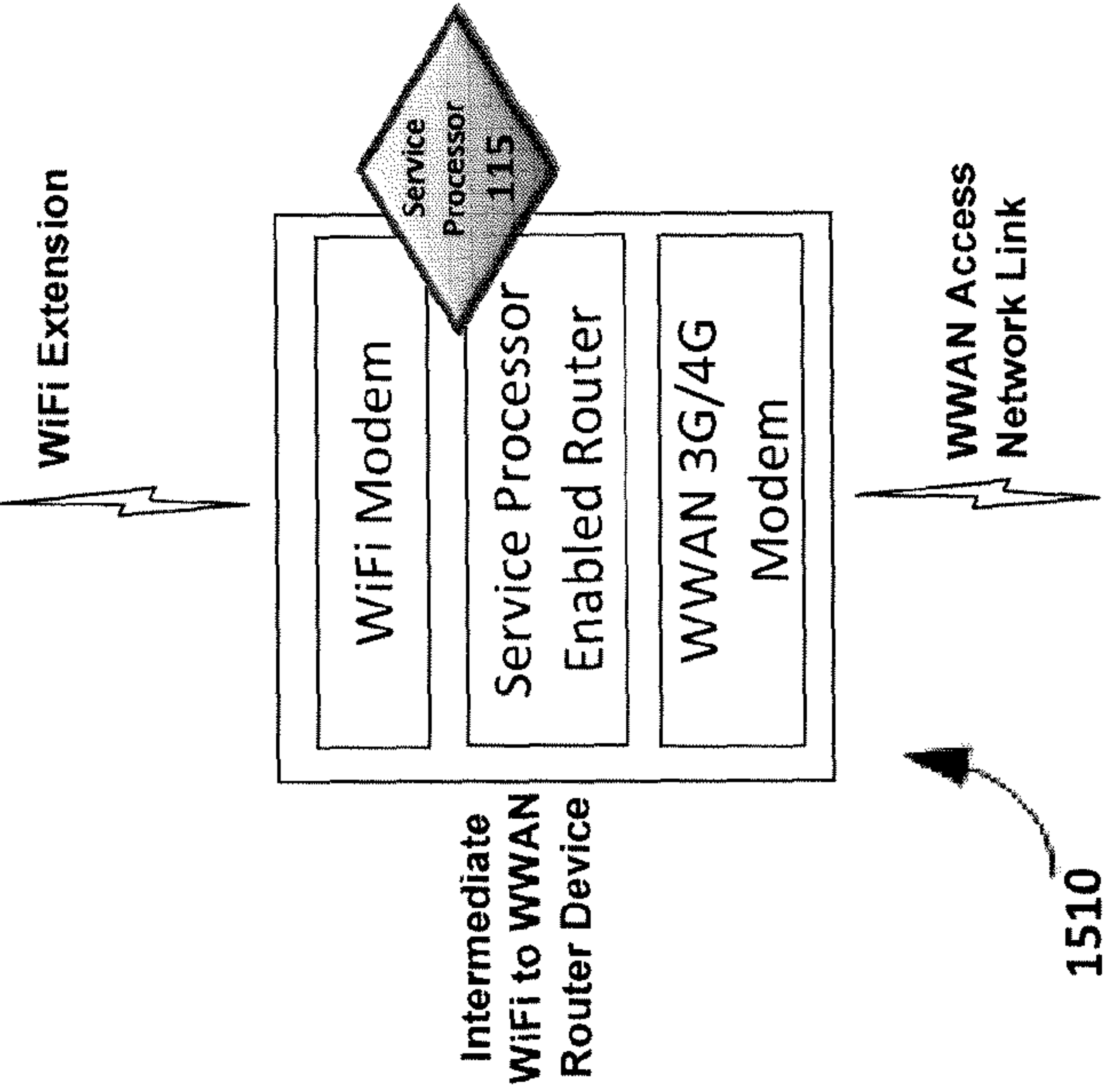


Figure 14

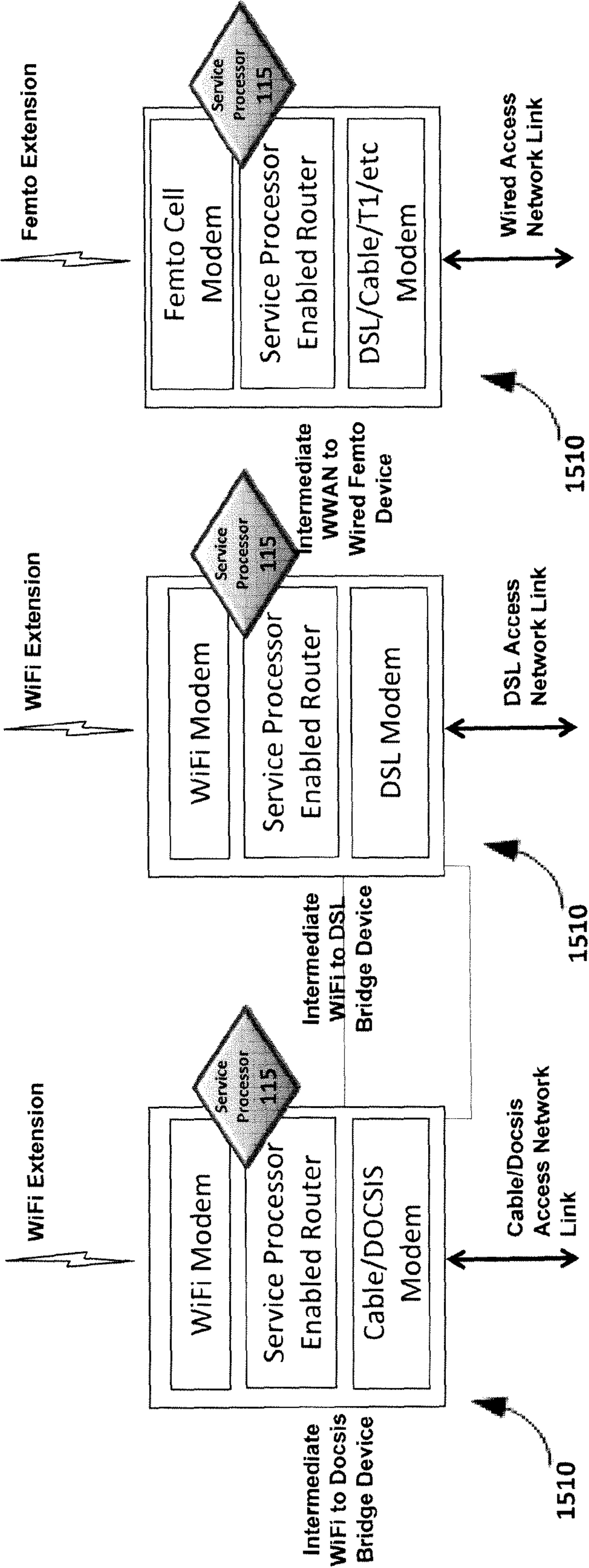


Figure 14(C)

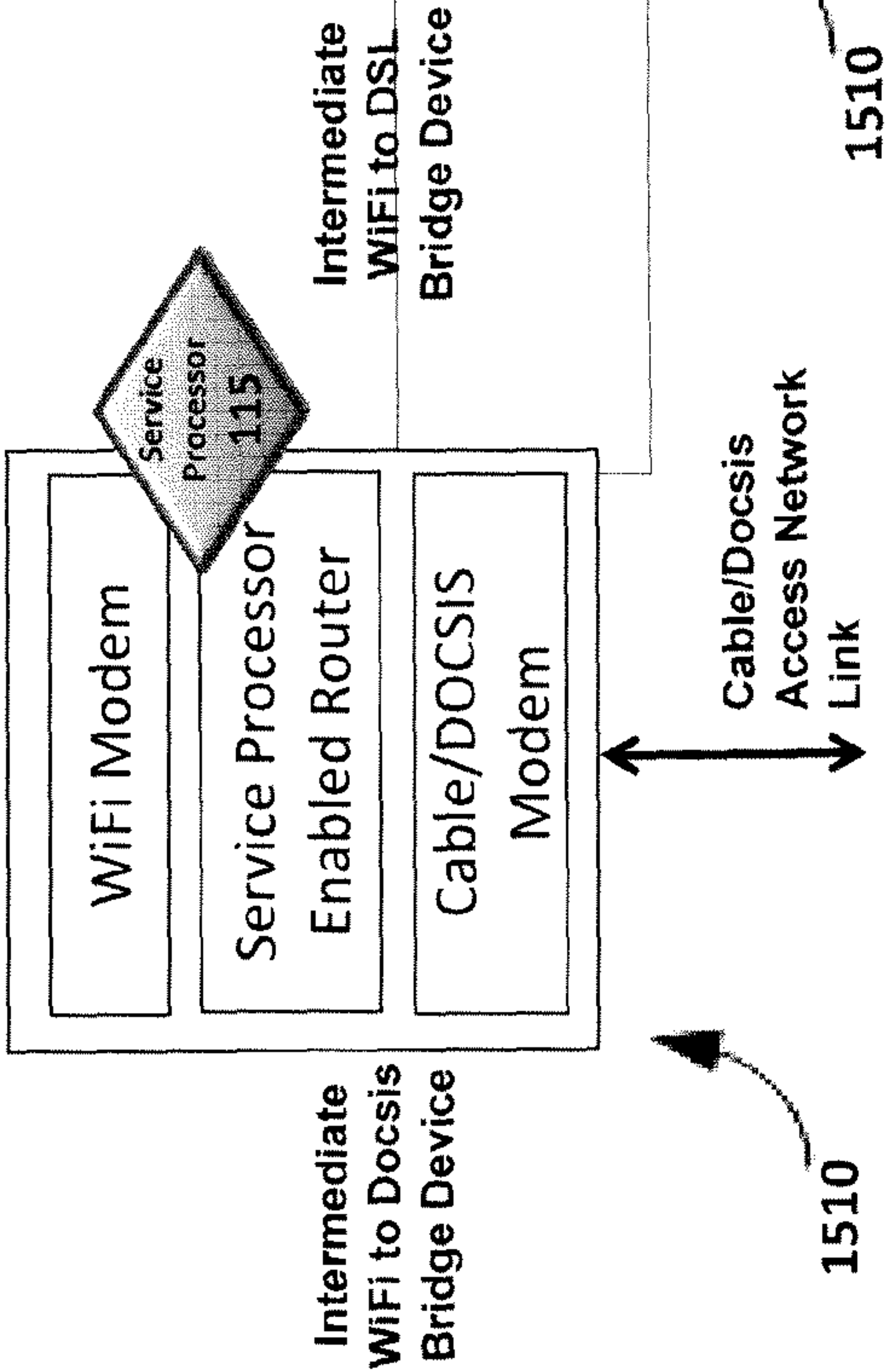


Figure 14 (D)

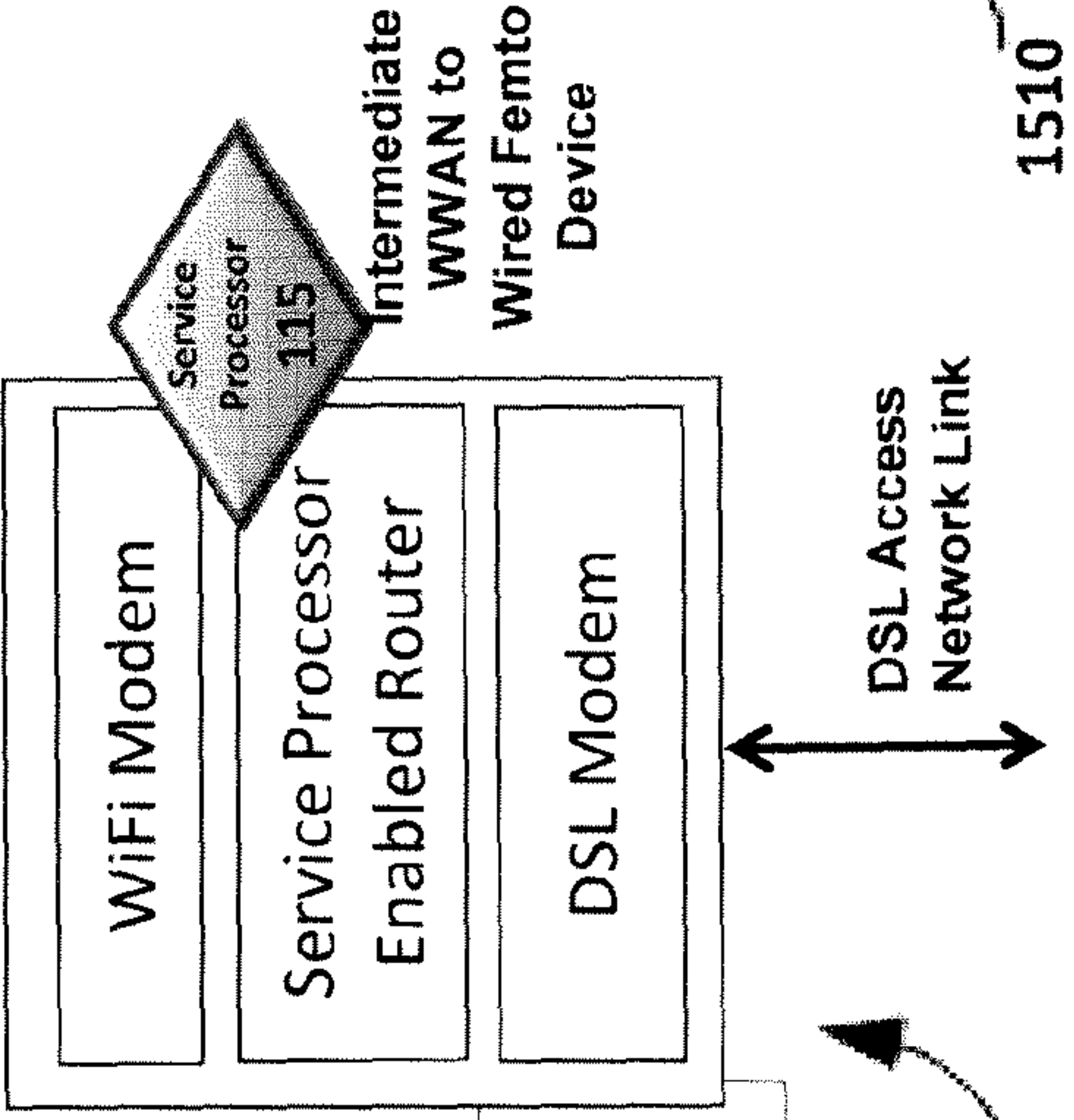
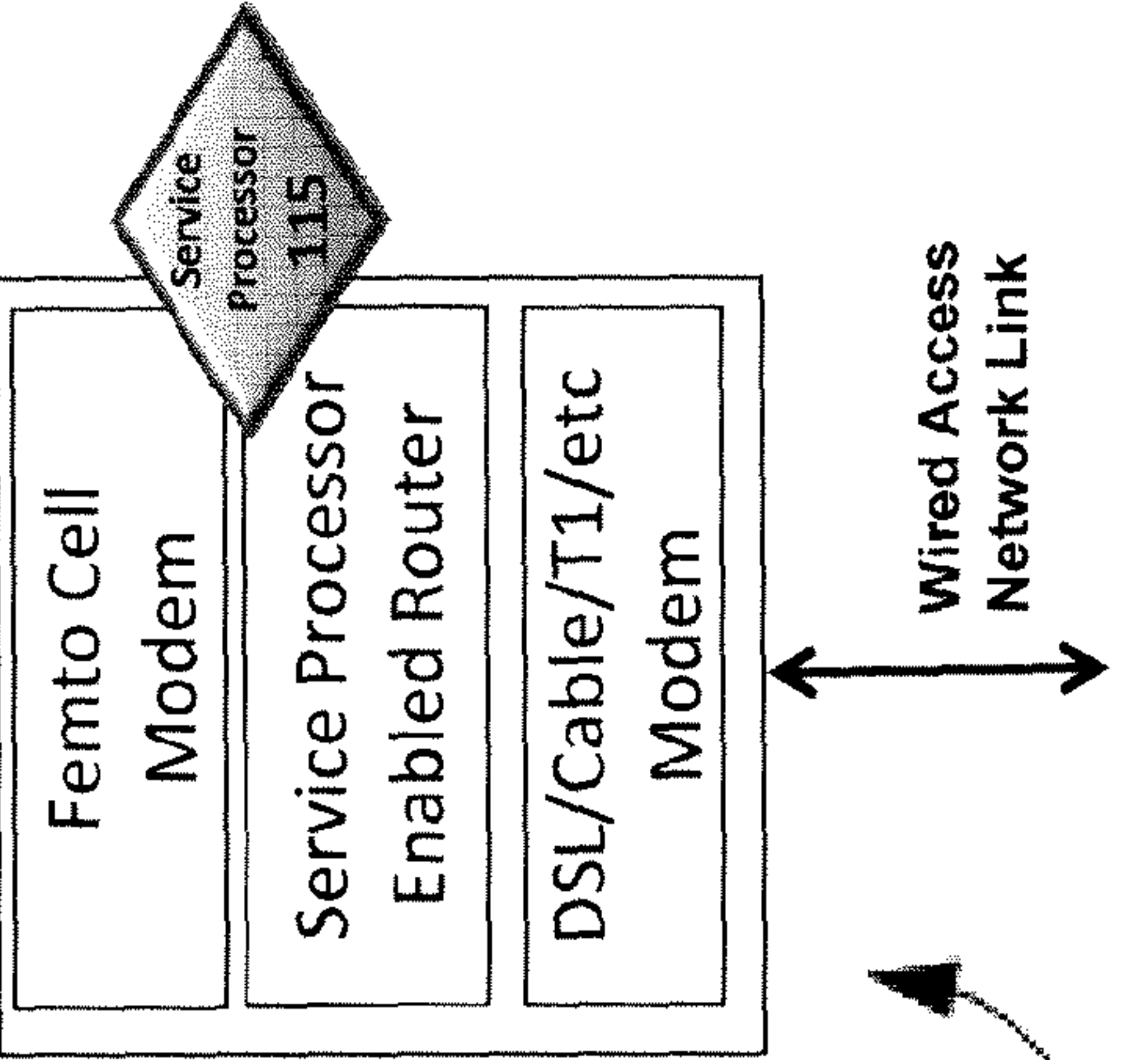


Figure 14 (E)



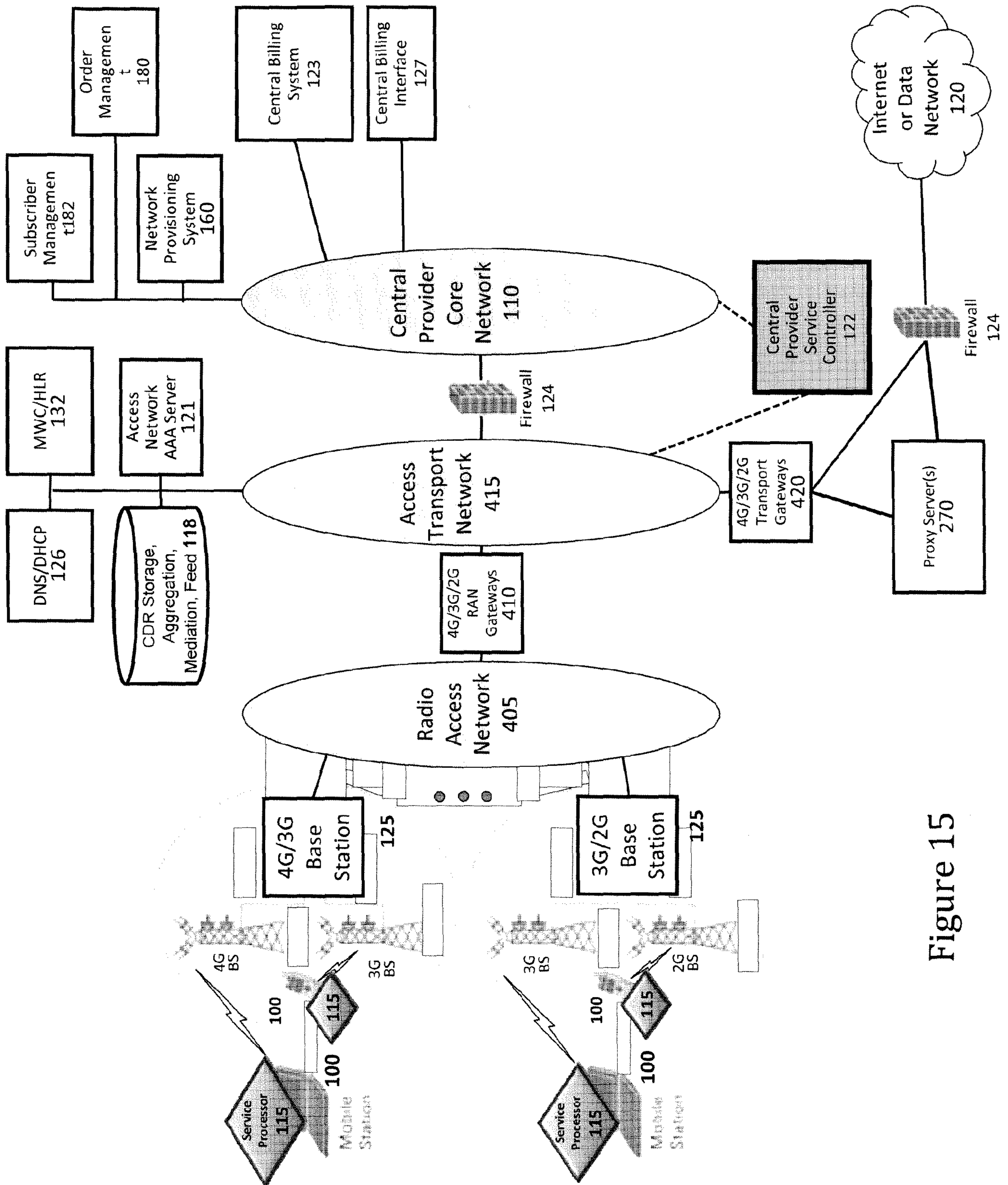


Figure 15

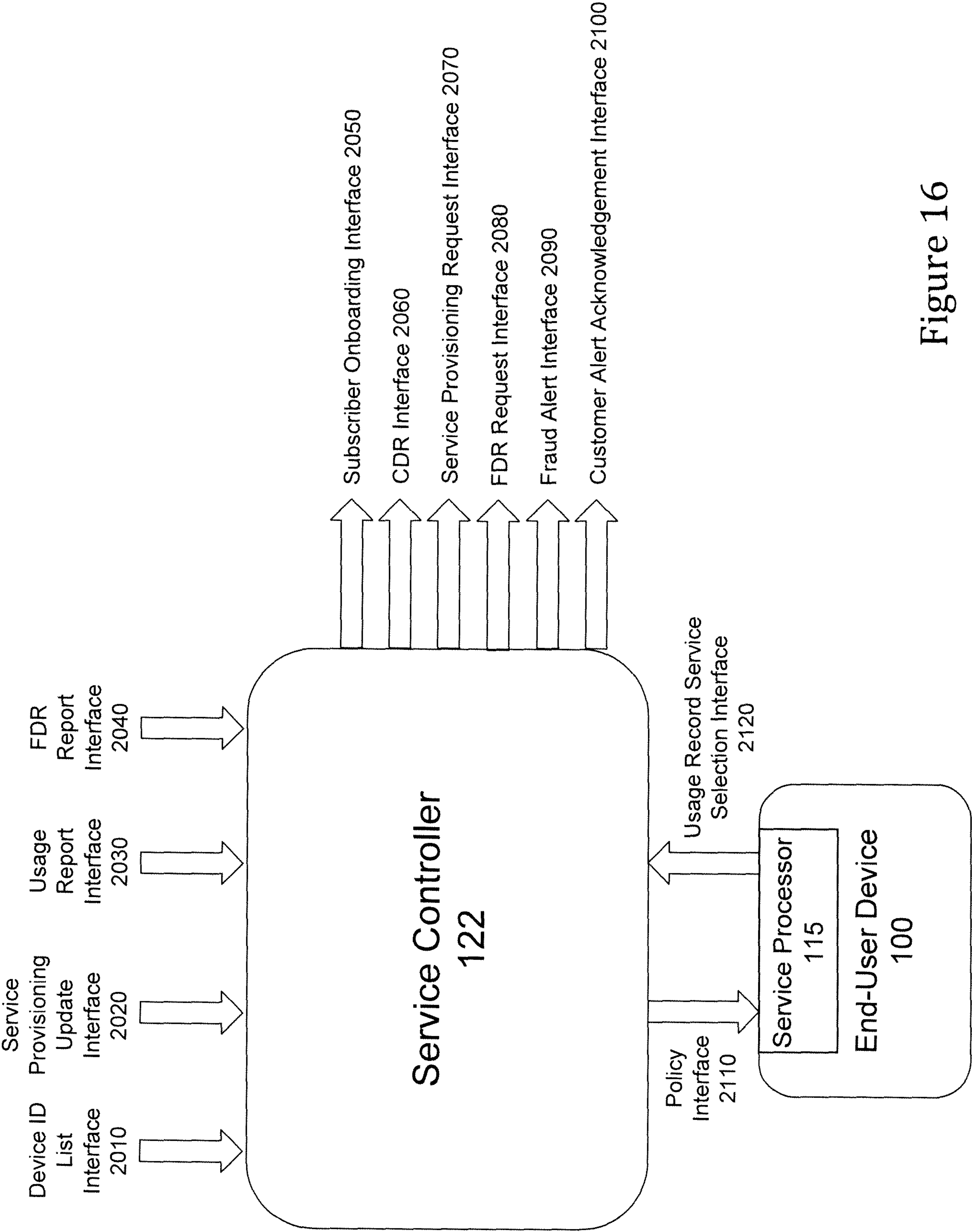


Figure 16

