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Device assisted CDR creation, aggregation, mediation and billing

Abstract

There is provided a system including a processor of a network device in communication with a wireless network. The processor is configured to collect device generated service usage information for one or more devices in wireless communication on the wireless network, and provide the device generated service usage information in a syntax and a communication protocol that can be used by other network devices to augment or replace network generated service usage information for the one or more devices in wireless communication on the wireless network.

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References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
5764693	12/1997	Taylor et al.	N/A	N/A

6421722	12/2001	Bauer et al.	N/A	N/A
6470182	12/2001	Nelson	N/A	N/A
6556823	12/2002	Clapton et al.	N/A	N/A
7392035	12/2007	Rahman	455/433	H04M 15/68
7633909	12/2008	Jones et al.	N/A	N/A
7672695	12/2009	Rainnie et al.	N/A	N/A
7849310	12/2009	Watt et al.	N/A	N/A
7881267	12/2010	Crosswy et al.	N/A	N/A
7962798	12/2010	Locasto et al.	N/A	N/A
8064417	12/2010	Maki	N/A	N/A
9032192	12/2014	Frank	N/A	N/A
2004/0123153	12/2003	Wright et al.	N/A	N/A
2004/0132427	12/2003	Lee	379/114.03	H04M 15/854
2004/0148237	12/2003	Bittmann et al.	N/A	N/A
2005/0101323	12/2004	De Beer	N/A	N/A
2005/0108534	12/2004	Bajikar et al.	N/A	N/A
2005/0144505	12/2004	Takeuchi et al.	N/A	N/A
2006/0015749	12/2005	Mittal	N/A	N/A
2006/0020781	12/2005	Scarlata et al.	N/A	N/A
2006/0112427	12/2005	Shahbazi	N/A	N/A
2006/0183461	12/2005	Pearce	N/A	N/A
2007/0006282	12/2006	Durham et al.	N/A	N/A
2007/0006289	12/2006	Limont et al.	N/A	N/A
2007/0061535	12/2006	Xu et al.	N/A	N/A
2007/0104169	12/2006	Polson	N/A	N/A
2007/0117538	12/2006	Weiser et al.	N/A	N/A
2007/0143827	12/2006	Nicodemus et al.	N/A	N/A
2007/0149252	12/2006	Jobs et al.	N/A	N/A
2007/0178888	12/2006	Alfano et al.	N/A	N/A
2007/0288989	12/2006	Aarnos et al.	N/A	N/A
2008/0052395	12/2007	Wright et al.	N/A	N/A
2008/0117958	12/2007	Pattenden et al.	N/A	N/A
2008/0122796	12/2007	Jobs et al.	N/A	N/A
2008/0244018	12/2007	Chen et al.	N/A	N/A
2008/0280589	12/2007	Cowper	455/406	H04M 15/00
2009/0077643	12/2008	Schmidt et al.	N/A	N/A
2009/0149165	12/2008	Minborg et al.	N/A	N/A
2009/0254465	12/2008	Oester	N/A	N/A
2009/0265754	12/2008	Hinds	N/A	N/A
2009/0300450	12/2008	Tzannes	N/A	N/A

OTHER PUBLICATIONS

Arm TrustZone Microprocessor Report, dated Aug. 25, 2033. cited by applicant

Arm TrustZone Paper, TrustZone: Integrated Hardware and Software Security, dated Jul. 2004. cited by applicant

Limont Prosecution History Excerpt, U.S. Appl. No. 11/171,850, filed Jun. 30, 2005. cited by applicant

Plaintiff's Infringement Contention in Case No. 6:23-CV-00352-JRG-RSP, *Headwater Research LLC* v. *Cellco Partnership,* d/b/a Verizon Wireless, Verizon Corporate Services Group Inc. (E.D. Tex, filed Jul. 28, 2023). cited by applicant

IPR2024-00809 Petition for Inter Partes Review of U.S. Pat. No. 9,198,042, filed Apr. 19, 2024. cited by applicant

IPR2024-00809 File History of Inter Partes Review of U.S. Pat. No. 9,198,042, filed Apr. 19, 2024. cited by applicant

Declaration and Curriculum Vitae of Dr. Patrick McDaniel. cited by applicant

Complaint, *Headwater Research LLC* v. *Samsung Electronics Co., Ltd. et al.*, 2-24-cv-00627, E.D. Tex., filed Aug. 2, 2024. cited by applicant

Excerpts from Smith, et al., 2005. "Virtual Machines: Versatile Platforms for Systems and Processes," Elsevier, Inc, 2005, ISBN 1-55860-910-5. cited by applicant

Declaration of June Munford. cited by applicant

Mallick, M., Mobile and Wireless Design Essentials (2003). cited by applicant

Anderson, R., Security Engineering: A Guide to Building Dependable Distributed Systems. (2001). cited by applicant

Jaeger, T., Operating System Security (Synthesis Lectures on Information Security, Privacy, and Trust) (2008). cited by applicant

Parziale, L., TCP/IP Tutorial and Technical Overview (IBM Redbooks) (2006). cited by applicant

McCanne, S. et al., The BSD Packet Filter: A New Architecture for User-level Packet Capture (1992). cited by applicant

Horak, R., Webster's New World Telecom Dictionary, (2008). cited by applicant

Ganz, A., et al., Multimedia Wireless Networks: Technologies, Standards, and QoS (2003). cited by applicant

Kwok, Y., et al., Wireless Internet and Mobile Computing: Interoperability and Performance (2007). cited by applicant

Brownlee et al., Traffic Flow Measurement: Architecture (1997). cited by applicant

Saltzer, J. H., The Protection of Information in Computer Systems, Proceedings of the IEEE (1975). cited by applicant

Tan, et al., An Empirical Study on the Capacity and Performance of 3G Networks (2008). cited by applicant

Wang, et al., Shield: Vulnerability-Driven Network Filters for Preventing Known Vulnerability Exploits, ACM SIGCOMM Computer Communication Review (2004). cited by applicant

Silberschatz et al., Operating System Concepts (7th ed. 2005). cited by applicant

Cheswick et al., Firewalls and Internet Security (2nd ed. 2003). cited by applicant

Koren et al., Fault Tolerant Systems (2007). cited by applicant

Loscri et al., Voice and Video Telephony Services in Smartphone, EURASIP Journal on Wireless Communications and Networking (2006). cited by applicant

Oxford University Press, A Dictionary of Computing, (6th ed. 2008) (defining "Agent"). cited by applicant

Downing et al., Dictionary of Computer and Internet Terms (9th ed. 2006) (defining "Agent"). cited by applicant

Kunie et al., "Low power architecture and design techniques for mobile handset LSI Medity M2," 748-753, 2008 Asia and South Pacific Design Automation Conference (2008). cited by applicant

M. Naruse et al., "A 65nm Single-Chip Application and Dual-Mode Baseband Processor with Partial Clock Activation and IP-MMU," 260-612, 2008 IEEE International Solid-State Circuits Conference—Digest of Technical Papers (2008). cited by applicant

Gertz et al., Handbook of Database Security: Applications and Trends, Springer (2007). cited by applicant

Oney, Programming The Microsoft Windows Driver Model (2nd ed. 2003). cited by applicant

Exhibit A, *Headwater Research LLC* v. *Samsung Electronics Co., Ltd. et al*, 2-24-cv-00627, E.D. Tex., filed Aug. 2, 2024. cited by applicant

IEEE 100, The Authoritative Dictionary of IEEE Standards Terms (7th ed. 2000). cited by applicant

Tanenbaum et al., Modern Operating Systems (2001). cited by applicant

The Secure Sockets Layer ("SSL") Protocol, V. 3.0, available at https://web.archive. org/web/19970614041044/http://home.netscape.com/eng/ssl3/ssl-toc.html and https://web.archive. org/web/19970617034012/http://home.netscape. com/eng/ssl3/3-SPEC.HTM#1. cited by applicant

IPR2025-00963 Petition For Inter Partes Review Of U.S. Pat. No. 10,028,144, filed May 5, 2025. cited by applicant

File History of IPR2025-00963 for Inter Partes Review Of U.S. Pat. No. 10,028,144, filed May 5, 2025. cited by applicant

Complaint, *Headwater Research LLC* v. *Samsung Elec-tronics Co., Ltd. et al*, 2-24-cv-00228, E.D. Tex., filed Apr. 3, 2024. cited by applicant

(Excerpts) Smith, et al., 2005. "Virtual Machines: Versa-tile Platforms for Systems and Processes," Elsevier, Inc, 2005, ISBN 1-55860-910-5. cited by applicant

(Excerpts) Telecom Dictionary, Athos Publishing, 2007. cited by applicant

(Excerpts) Eberspächer, Jörg (2001). GSM Switching, Services and Protocols, Second Edition. John Wiley & Sons Ltd. ISBN: 978-0-470-85394-8. cited by applicant

3rd Generation Partnership Project; Technical Specifica-tion Group Terminals; "Characteristics of the USIM ap-plication" (Release 7), 3GPP TS 31.102 V7.0.0 ("3GPP USIM"). cited by applicant

Kasper, et al., Feb. 2008. "Subscriber authentication in cellular networks with trusted virtual sims." In 2008 10th International Conference on Advanced Communication Technology (vol. 2, pp. 903-908). IEEE. cited by applicant

TCG Mobile Reference Architecture, version 1.0, Revi-sion 1, Jun. 12, 2007. ("TCG Mobile Reference Archi-tecture"). cited by applicant

TCG Mobile Trusted Module Specification, version 1.0, Revision 6, Jun. 26, 2008. ("TCG Mobile Trusted Mod-ule Specification"). cited by applicant

Stone, G.N., Lundy, B. and Xie, G.G., 2001. Network policy languages: a survey and a new approach. IEEE network, 15(1), pp. 10-21. cited by applicant

David K. Gifford. 1982. Cryptographic sealing for infor-mation secrecy and authentication. Commun. ACM 25, Apr. 4, 1982, 274-286. https://doi.org/10.1145/358468.358493. cited by applicant

Jansen, Wayne A. and Richard P. Ayers. "Forensic Tools for Mobile Phone Subscriber Identity Modules." J. Digit. Forensics Secur. Law 1 (2006): 75-94. cited by applicant

National Institute of Standards and Technology. 2001. Security Requirements for Cryptographic Modules, downloaded from the Internet at https://nvl-pubs.nist.gov/nistpubs/FIPS/NIST.FIPS. 140-2.pdf on Dec. 5, 2024. cited by applicant

Verma, et al., (2002). Policy-based management of con-tent distribution networks. IEEE network, 16(2), 34-39. cited by applicant

Lobo, et al., (1999). A policy description language. AAAI/IAAI, 1999, 291-298. cited by applicant

Westerinen, et al., IETF RFC 3198, Terminology for Pol-icy-Based Management, Nov. 2001, downloaded from the Internet on May 27, 2024. cited by applicant

(Excerpts) Keith Mayes and Konstantinos Markantona-kis. 2008. Smart Cards, Tokens, Security and Applica-tions (1st. ed.). cited by applicant

(Excerpts) Gasser, Morrie. Building a Secure Computer System. New York, NY: Van Nostrand Reinhold, 1988. ("Gasser"). cited by applicant

(Excerpts) Malhotra, Ravi. 2002. IP Routing: Help for Network Administrators. O'Reilly Media. ISBN: 978-0-596-00275-0 ("Malhotra"). cited by applicant

Jude, Michael. "Policy-Based Management: Beyond the Hype." Business Communications Review 31.3 (2001): 52-56. ("Jude"). cited by applicant

Merkle, Ralph C. 1978. Secure communications over in-secure channels. Commun. ACM 21, Apr. 4, 1978, 294-299. https://doi.org/10.1145/359460.359473 ("Merkle"). cited by applicant

ARM. 2004. PrimeCell Infrastructure AMBA 3 TrustZone Protection Controller (BP147) Revision:

r0p0 Technical Overview, downloaded from the Internet at https://documentation-service.arm.com/static/5e9565afc8052b1608762aae%3Ftoken%3D&ved=2ahUKEwiZq56_3pGKAxVUCnkGHcR9OGIQFnoECAwQAQ&usg=AOvVaw2PG8jUG9TU8fpiRxmGKNyM on Dec. 5, 2024. cited by applicant

Network Associates, Inc. 1999. PGP, Version 6.5.1. An Introduction to Cryptography. cited by applicant

Stuart E. Madnick and John J. Donovan. 1973. Applica-tion and analysis of the virtual machine approach to in-formation system security and isolation. In Proceedings of the workshop on virtual computer systems. Associa-tion for Computing Machinery, New York, NY, USA, 210-224. https://doi.org/10.1145/800122.803961. cited by applicant

European Telecommunications Standards Institute. 1998. Terrestrial Trunked Radio (TETRA); Security Aspects; Subscriber Identity Module to Mobile Equipment (SIM-ME) interface. ETSI ETS 300 812 ed.1 (Nov. 1998), down-loaded from the Internet at https://www.etsi.org/deliver/etsi_i_ets/300800_300899/300812/01_20_9826/ets_300812e01c.pdf on Dec. 12, 2024. cited by applicant

IETF RFC 1122, Requirements for Internet Hosts—Com-munication Layers, Oct. 1989, downloaded from the internet at https://datatracker.ietf.org/doc/html/rfc1122 on Dec. 12, 2024. cited by applicant

IETF RFC 793, Transmission Control Protocol, Sep. 1981, downloaded from the internet at https://www.ietf.org/rfc/rfc793.txt on Dec. 11, 2024. cited by applicant

Smith, et al., 2005. "The architecture of virtual machines. Computer," 38(5). cited by applicant

ISO/IEC 7498-1, "Information technology—Open Sys-tems Interconnection—Basic Reference Model: The Basic Model," downloaded from the internet at https://www.ecma-international.org/wp-content/up-loads/s020269e.pdf on Jan. 10, 2025. cited by applicant

Gonçalves, et al., Oct. 2009. A graphical user inter-face for policy composition in CIM-SPL. In 2009 Inter-national Conference on Ultra Modern Telecommunications & Workshops (pp. 1-7). IEEE. cited by applicant

Agrawal, et al., May 2007. Issues in designing a policy language for distributed management of IT infrastruc-tures. In 2007 10th IFIP/IEEE International Symposium on Integrated Network Management (pp. 30-39). IEEE. cited by applicant

File History of IPR2025-00482, filed Jan. 28, 2025. cited by applicant

Petition for Inter Partes Review in IPR2025-00482, filed Jan. 28, 2025. cited by applicant

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Background/Summary

INCORPORATION BY REFERENCE (1) This application incorporates by reference the following U.S. Non-Provisional Applications: U.S. patent application Ser. No. 12/695,019, entitled DEVICE ASSISTED CDR CREATION, AGGREGATION, MEDIATION AND BILLING, filed Jan. 27, 2010 (now U.S. Pat. No. 8,275,830); U.S. patent application Ser. No. 12/380,778, entitled VERIFIABLE DEVICE ASSISTED SERVICE USAGE BILLING WITH INTEGRATED ACCOUNTING, MEDIATION ACCOUNTING, AND MULTI-ACCOUNT, filed on Mar. 2, 2009 (now U.S. Pat. No. 8,321,526); and U.S. patent application Ser. No. 12/380,771, entitled VERIFIABLE SERVICE BILLING FOR INTERMEDIATE NETWORKING DEVICES, filed on Mar. 2, 2009 (now U.S. Pat. No. 8,023,425). (2) This application also incorporates by reference the

following U.S. Provisional Applications: U.S. Provisional Patent Application No. 61/206,354 entitled SERVICES POLICY COMMUNICATION SYSTEM AND METHOD filed Jan. 28, 2009; U.S. Provisional Patent Application No. 61/206,944 entitled SERVICES POLICY COMMUNICATION SYSTEM AND METHOD filed Feb. 4, 2009; U.S. Provisional Application No. 61/207,393 entitled SERVICES POLICY COMMUNICATION SYSTEM AND METHOD filed Feb. 10, 2009; U.S. Provisional Patent Application No. 61/207,739 entitled SERVICES POLICY COMMUNICATION SYSTEM AND METHOD filed on Feb. 13, 2009; U.S. Provisional Patent Application No. 61/270,353 entitled DEVICE ASSISTED CDR CREATION, AGGREGATION, MEDIATION AND BILLING filed on Jul. 6, 2009; and U.S. Provisional Patent Application No. 61/264,126 entitled DEVICE ASSISTED SERVICES ACTIVITY MAP filed on Nov. 24, 2009.

BACKGROUND OF THE INVENTION

(1) 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.

(2) 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.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) Various embodiments are disclosed in the following detailed description and the accompanying drawings.

(2) FIGS. **1**A, **1**B, and **1**C illustrate a wireless network architecture for providing device assisted CDR creation, aggregation, mediation and billing in accordance with some embodiments.

(3) FIGS. **2**A, **2**B, and **2**C illustrate another wireless network architecture for providing device assisted CDR creation, aggregation, mediation and billing in accordance with some embodiments.

(4) FIG. **3** illustrates another wireless network architecture for providing device assisted CDR creation, aggregation, mediation and billing in accordance with some embodiments.

(5) FIG. **4** illustrates provisioning of a wireless network for providing device assisted CDR creation, aggregation, mediation and billing in accordance with some embodiments.

(6) FIG. **5** illustrates a network architecture for providing device assisted CDRs in accordance with some embodiments.

(7) FIG. **6** illustrates another network architecture for providing device assisted CDRs in accordance with some embodiments.

(8) FIG. **7** illustrates another network architecture for providing device assisted CDRs in accordance with some embodiments.

(9) FIG. **8** illustrates another network architecture for providing device assisted CDRs in accordance with some embodiments.

(10) FIG. **9** is a functional diagram illustrating a device based service processor and a service

controller in accordance with some embodiments.

(11) FIGS. **10**A and **10**B provide a table summarizing various service processer functional elements in accordance with some embodiments.

(12) FIGS. **11**A and **11**B provide a table summarizing various service controller functional elements in accordance with some embodiments.

(13) FIG. **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.

(14) FIG. **13** illustrates an embodiment similar to FIG. **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.

(15) FIGS. **14**A through **14**E illustrate 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.

(16) FIG. **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.

DETAILED DESCRIPTION

(17) 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.

(18) 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.

(19) 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.

(20) 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.

(21) In some embodiments, network user capacity is increased and user service costs are reduced by managing and billing for service consumption in a more refined manner (e.g., to satisfy network neutrality requirements). By managing service consumption in a user friendly manner, the overall service capacity required to satisfy the user device needs can be tailored more closely to the needs of a given user thereby reducing user service costs and increasing service provider profits. For example, managing service usage while maintaining user satisfaction includes service usage policy implementation and policy management to identify, manage and bill for service usage categories, such as total traffic consumption, content downloads, application usage, information or content subscription services, electronic commerce transactions, people or asset tracking services or machine to machine networking services. As described herein, service activity is used to refer to any service usage or traffic usage that can be associated with, for example, an application; a network communication end point, such as an address, uniform resource locator (URL) or other identifier with which the device is communicating; a traffic content type; a transaction where content or other material, information or goods are transacted, purchased, reserved, ordered or exchanged; a download, upload or file transfer; email, text, SMS, IMS or other messaging activity or usage; VOIP services; video services; a device usage event that generates a billing event; service usage associated with a bill by account activity (also referred to as billing by account) as described herein; device location; device service usage patterns, device user interface (UI) discovery patterns, content usage patterns or other characterizations of device usage; or other categories of user or device activity that can be identified, monitored, recorded, reported, controlled or processed in accordance with a set of verifiable service control policies. As will be apparent to one of ordinary skill in the art in view of the embodiments described herein, some embodiments identify various service activities for the purpose of decomposing overall service usage into finer sub-categories of activities that can be verifiably monitored, categorized, cataloged, reported, controlled, monetized and used for end user notification in a manner that results in superior optimization of the service capabilities for various levels of service cost or for various types of devices or groups. In some embodiments, it will be apparent to one of ordinary skill in the art that the terms service activity or service usage are associated with categorizing and possibly monitoring or controlling data traffic, application usage, communication with certain network end points, or transactions, and it will also be apparent that in some embodiments the term service activity is intended to include one or more of the broader aspects listed above. The shortened term service usage can be used interchangeably with service activity, but neither term is intended in general to exclude any aspect of the other. In some cases, where the terms service usage or service activity are used, more specific descriptors such as traffic usage, application usage, website usage, and other service usage examples are also used to provide more specific examples or focus in on a particular element of the more encompassing terms.

(22) 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.

(23) 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).

(24) 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.

(25) 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**).

(26) 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.

(27) 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.

(28) 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.

(29) 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 base stations (BTS/BSCs) **125**A, **125**B, **125**E, **125**F, and **125**G, 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.

(30) 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.

(31) 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.

(32) 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).

(33) 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.

(34) 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.

(35) 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.

(36) 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**.

(37) 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.

(38) 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.

(39) 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.

(40) 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.

(41) 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 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.

(42) 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.

(43) FIG. **1** illustrates a wireless network architecture for providing device assisted CDR creation, aggregation, mediation and billing in accordance with some embodiments. As shown, FIG. **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**A and **125**B 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 FIG. **1**).

(44) As shown in FIG. **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 FIG. **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 FIG. **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 stations **125**A and **125**B in FIG. **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 FIG. **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.

(45) 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).

(46) 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.

(47) 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**.

(48) 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**.

(49) 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**.

(50) 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).

(51) 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).

(52) 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.

(53) 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 FIG. **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.

(54) 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**.

(55) 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.

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

(57) FIG. **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 FIG. **3**, the 4G/3G and 3G/2G base stations/nodes **125**E and **125**F 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**.

(58) As shown, FIG. **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.

(59) FIG. **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 FIG. **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 **425**, and/or base station controller **125**G. In some embodiments, other network elements generate/receive/store device assisted CDRs.

(60) 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.

(61) 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).

(62) FIG. **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 FIG. **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.

(63) 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 FIG. **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.

(64) FIG. **6** illustrates another network architecture for providing device assisted CDRs in accordance with some embodiments. FIG. **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.

(65) 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.

(66) FIG. **7** illustrates another network architecture for providing device assisted CDRs in accordance with some embodiments. FIG. **7** also shows the communication of device assisted CDRs and network generated CDRs using solid and dashed lines with arrows, respectively. FIG. **7** is similar to FIG. **6**, except as shown in FIG. **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**.

(67) FIG. **8** illustrates another network architecture for providing device assisted CDRs in accordance with some embodiments. FIG. **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 FIG. **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 FIG. **5** are implemented as a new layer of rules in a new network function, shown as secondary DAS CDR aggregation mediation **118**A, 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 **118**A) 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.

(68) FIG. **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 FIG. **9** are described below with respect to FIGS. **10** and **11**.

(69) As shown in FIG. **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.

(70) In some embodiments, the service control device link **1691** agent messages are transmitted asynchronously as they are generated by one or more of the service agents. In some embodiments, the service control device link **1691** performs collection or buffering of agent messages between transmissions. In some embodiments, the service control device link **1691** determines when to transmit based potentially on several parameters including, for example, one or more of the following parameters: periodic timer trigger, waiting until a certain amount of service usage or traffic usage has occurred, responding to a service controller message, responding to a service controller request, initiated by one or more agents, initiated by a verification error condition, initiated by some other error or status condition. In some embodiments, once a transmission trigger has occurred, the service control device link **1691** assembles all buffered agent communications and frames the communications.

(71) In some embodiments, the transmission trigger is controlled by waiting for an amount of service usage, such as waiting until a certain amount of data traffic has passed, which reduces the control plane communication channel traffic usage to a fraction of the data plane traffic. For example, this approach preserves network capacity and reduces service cost even in traffic scenarios in which data traffic is light.

(72) In some embodiments, the transmission trigger is based on waiting for an amount of service usage, and also including a minimum transmission rate that triggers a transmission according to one or more of the following parameters: a maximum time between transmissions clock to keep the service processor **115** in communication with the service controller **122** when little or no service usage is occurring, a polling request of some kind from the service controller **122**, a response to a service controller heartbeat, a transmission generated by a service verification error event, or a transmission generated by some other asynchronous event with time critical service processor **115** (or service controller **122**) messaging needs, such as a transaction or service billing event or a user request. For example, service control plane traffic down is reduced to a relatively inexpensive and capacity conserving trickle when device **100** data traffic is not significant. At the same time, this approach also provides an effective flow of real time or near real-time service control plane traffic that is both cost and capacity efficient, because the service control plane traffic is a relatively small percentage of the data plane traffic when data plane traffic usage is heavy. For example, when data plane traffic usage is heavy is generally the time when close monitoring of service policy implementation verification or compromise prevention can be particularly important and by keeping the control plane overhead to a fraction of data plane traffic close monitoring and control of services are maintained at a reasonable cost in terms of percentage of both bandwidth used and network capacity. In some embodiments, the service usage or service activity trigger occurs based on some other measure than traffic usage, such as a number of messages transacted, one or more billing events, number of files downloaded, number of applications run or time that an application has been running, usage of one or more specified applications, GPS coordinate changes, roaming event, an event related to another network connection to the device and/or other service related measures.

(73) As shown in FIG. **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 FIG. **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.

(74) 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.

(75) As shown in FIG. **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.

(76) 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.

(77) 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.

(78) 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.

(79) As shown in FIG. **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.

(80) As shown in FIG. **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.

(81) 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.

(82) As shown in FIG. **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.

(83) As shown in FIG. **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.

(84) As shown in FIG. **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.

(85) As shown in FIG. **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.

(86) As shown in FIG. **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**).

(87) As shown in FIG. **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.

(88) As shown in FIG. **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**.

(89) As shown in FIG. **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.

(90) 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.

(91) In some embodiments, the device **100** is capable of connecting to more than one network and device service policies are potentially changed based on which network the device is connected to at the time. In some embodiments, the network control plane servers detect a network connection change and initiate the service policy implementation established for the second network. In some embodiments, the device based adaptive policy control agent, as described herein (e.g., policy control agent **1692**), detects network connection changes and implements the service policies established for the second network.

(92) In some embodiments, when more than one access network is available, the network is chosen based on which network is most preferred according to a network preference list or according to which network that optimizes a network cost function. For example, the network preference list can be pre-established by the service provide and/or the user and/or later modified/adjusted by either the service provider and/or the user. For example, the cost function can be based on determining a minimum service cost, maximum network performance, whether or not the user or device has access to the network, maximizing service provider connection benefit, reducing connections to alternative paid service providers, and/or any other cost related criteria for network selection purposes.

(93) In some embodiments, the device **100** detects when one or more preferred networks are not available, implements a network selection function or intercepts other network selection functions, and offers a connection to the available service network that is highest on a preference list. For example, the preference list can be set by the service provider, the user and/or the service subscriber. In some embodiments, a notification is provided to the device/user when the device is not connected to a network (e.g., indicating in a pop-up/bubble or other UI based display a notification, such as "You are not connected to the network. Click here to learn more, get free trial, use a session, sign-up for service"). In some embodiments, the notification content can be determined based on usage service patterns, locally stored and/or programmable logic on the device and/or a server (e.g., device reports that user is not connected and WWAN is available). Decisions on what bubble to present when may be in pre-stored logic on device.

(94) In some embodiments, service policies are automatically adapted based on the network to which device **100** is connected. For example, the device can be a cellular communication based device connected to a macrocell, a microcell, a picocell, or a femtocell (e.g., femto cells generally provide a low power, small area cellular network used, for example, in homes or offices, which, for example, can be used as an alternative to Wi-Fi access). In some embodiments, service monitoring

agent **1696** and/or billing agent **1695** modify service usage counting and/or billing based on whether the device is connected to a macrocell, microcell, picocell or femtocell. In some embodiments, the device recognizes which type of network it is currently connecting to (e.g., looking up in a local or network table for the current base station connected to, and/or the information is broadcast to the device upon the connection with the base station), that is, whether it is a macrocell, microcell, picocell or femtocell. In other embodiments, the device does not recognize which type of network it is currently connected to, but reports its current base station, and the network uses a network lookup function to determine which type of network it is connected to. In some embodiments, the device adjusts the billing based on the type of network it is connected to, or in other embodiments, the device calculates an offset to such billing based on the type of network it is connected to, and/or in other embodiments, the device records such service usage associated with the type of network it is connected to and the network billing can adjust the billing accordingly. For example, the billing can be lower for service data usage over a femtocell versus a macrocell. In some embodiments, service policies are adjusted based on the type of network that the device is connected, such as billing, user notification, data usage/bandwidth, throttling, time of day, who owns the cellular network connection (e.g., user's home femtocell, or user's work femtocell, or a commercial business's femtocell like a coffee shop or any other common area like an airport) and/or any other service policy can be different for a femtocell connection (or for any other type of connection, such as a macrocell, microcell, or picocell). In some embodiments, the local service usage counter is adjusted based on the type of network (and/or based on the time of day of such service activity) that the device is connected, such as billing, user notification, data usage/bandwidth, and/or any other service policy can be different for a femtocell connection (or for any other type of connection, such as a macrocell, microcell, or picocell). In some embodiments, the service policies and/or billing policies are adjusted based on network congestion.

(95) As shown in FIG. **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 FIG. **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**.

(96) 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.

(97) 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 FIG. **9**. 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.

(98) FIG. **10** provides a table summarizing various service processer **115** functional elements in accordance with some embodiments. Many of these agents are similarly described above, and the table shown in FIG. **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 FIG. **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.

(99) FIG. **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 FIG. **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 FIG. **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.

(100) FIG. **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 FIG. **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.

(101) 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.

(102) It will be appreciated that although the implementation/use of any or all of the measurement points illustrated in FIG. **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).

(103) Referring to FIG. **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 FIG. **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 FIG. **12**.

(104) As shown in FIG. **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.

(105) As shown in FIG. **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.

(106) FIG. **13** illustrates an embodiment similar to FIG. **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 FIG. **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 FIG. **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 of 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.

(107) Referring to FIG. **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 FIG. **13**.

(108) A complication arises when upper layer reliable communication protocols, such as TCP, are employed in the networking stack in which the downstream transmitting end repeats the packet transmission if the receiving TCP protocol stack does not send a packet receipt acknowledge (ACK) within a certain period of time. If packets are arbitrarily delayed or dropped, then the TCP

re-transmission traffic can reduce, completely eliminate or even reverse the network capacity advantage gained by reducing the average traffic speed or other transmission quality measure for one or more service activities. To solve this problem, in some embodiments, the packet traffic control parameters (e.g., downstream delay, drops, burst length, burst frequency and/or burst jitter) are optimized for TCP re-transmission efficiency so that changes in traffic control access bandwidth or speed for one or more service activities are implemented in such a manner that the TCP re-transmission delay at the network transmitting end adapts to be long enough so that wasted packet re-transmission bandwidth is reduced. In addition, and either in combination or in isolation, in some embodiments, the packet traffic control parameters (e.g., downstream delay, drops, burst length, burst frequency and/or burst jitter) can be adjusted so that the access network downstream MAC and/or PHY efficiencies are optimized.

(109) Numerous other embodiments for the detailed implementation of packet flow processing in both downstream and upstream will be apparent to one of ordinary skill in the art in view of the various embodiments described herein. In some embodiments, as described herein, the following are provided: (A) traffic shaping is performed in a verifiable manner, (B) traffic shaping is performed in a manner that results in improved network capacity by taking into account to some degree the manner in which the access network PHY layer and/or MAC layer responds to packet parameters (e.g. burst delay, burst drops, burst length, burst frequency and/or burst jitter), (C) traffic shaping is performed in a manner that results in improved network capacity by taking into account how the packet parameters (e.g., burst delay, burst drops, burst length, burst frequency and/or burst jitter) impact layer 3 and higher ACK protocol or other network protocol network capacity efficiencies, (D) packet shaping is performed in a manner that is aware of and optimized for the particular type of communication protocol or packets being sent (e.g., TCP packets can be dropped to slow the application rate of transfer whereas UDP packets are never dropped, because there is no re-transmission), (E) a virtual or literal packet tagging system is used in a verifiable traffic shaping service control system to provide a deeper level of service monitoring and control or to simplify the processing of the packets, and/or (F) starting with these low level packet processing, traffic control or access control building blocks one or more additional layers of higher level policy control can be added on the device or in the network to create service profiles for the service provider network that define complete services, such as ambient services and many other variations of service profile settings that each define a device or user service experience and can be associated with a billing plan. For example, the use of higher layers of service profile control to form more complete service solutions starting with these relatively simple low-level traffic control, access control or firewall processing steps or functions is also described herein.

(110) FIGS. **14**A through **14**E illustrate 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, FIGS. **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**.

(111) 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 FIG. **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.

(112) Referring now to FIGS. **14**B through **14**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**.

(113) As shown in FIG. **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 FIG. **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 FIG. **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 FIG. **14**E.

(114) FIG. **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, FIG. **15** 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.

(115) 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.

(116) 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.

(117) 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.

(118) 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.

(119) 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.

(120) 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.

(121) 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.

(122) 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 posses, 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.

(123) 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, n 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.

(124) 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.

(125) 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.

(126) 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.

(127) 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.

(128) 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.

(129) 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.

(130) 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.

(131) 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.

(132) 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 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/outer. 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.

(133) 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.

(134) In some embodiments, the coordination of the device service controller traffic control elements with a proxy server/outer 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.

(135) 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.

(136) 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.

(137) 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).

(138) 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

1. A method for use by a mobile end-user device in communication with a mobile access network, the method comprising: determining a first service activity associated with a first Internet data traffic flow of a plurality of Internet data traffic flows communicated between the mobile end-user device and the mobile access network; in response to determining the first service activity, allocating first data usage by the first Internet data traffic flow to the first service activity; determining a second service activity associated with a second Internet data traffic flow of the plurality of Internet data traffic flows communicated between the mobile end-user device and the mobile access network; in response to determining the second service activity, allocating second data usage by the second Internet data traffic flow to the second service activity; generating a first data usage record including the first data usage identified with the first service activity, and a second data usage record including the second data usage identified with the second service activity; and sending the first data usage record and the second data usage record to a network element.

2. The method of claim 1, wherein determining that the first service activity is associated with the first Internet data traffic flow comprises inspecting one or more Internet data packets of the first Internet data traffic flow.

3. The method of claim 2, wherein inspecting the one or more Internet data packets of the first Internet data traffic flow comprises extracting a uniform resource locator (URL) identifier, a referring tag, or a referring header.

4. The method of claim 1, wherein determining that the first service activity is associated with the first Internet data traffic flow comprises detecting a proximity in time between the first Internet data traffic flow and other traffic identified as being associated with the first service activity.

5. The method of claim 1, further comprising: applying a first traffic control to the first Internet data traffic flow in accordance with a traffic control service policy associated with first service activity.

6. The method of claim 1, further comprising: providing, a notification through a user interface of the mobile end-user device, indicating whether one or more of the plurality of Internet data traffic flows is associated with at least one of the first service activity or the second service activity.

7. The method of claim 1, further comprising: blocking the first Internet data traffic flow based on association with the first service activity.

8. The method of claim 7, further comprising: providing, a notification through a user interface of the mobile end-user device, indicating that the first Internet data traffic flow was blocked.

9. The method of claim 1, wherein the first service activity is associated with a first application on the mobile end-user device, and the second service activity is associated with a second application on the mobile end-user device.

10. The method of claim 1, wherein the first service activity is associated with an address or a uniform resource locator (URL) with which the mobile end-user device is communicating.

11. A mobile end-user device comprising: one or more processors configured to: determine a first service activity associated with a first Internet data traffic flow of a plurality of Internet data traffic flows communicated between the mobile end-user device and a mobile access network; in response to determining the first service activity, allocate first data usage by the first Internet data traffic flow to the first service activity; determine a second service activity associated with a second

Internet data traffic flow of the plurality of Internet data traffic flows communicated between the mobile end-user device and the mobile access network; in response to determining the second service activity, allocate second data usage by the second Internet data traffic flow to the second service activity; generate a first data usage record including the first data usage identified with the first service activity, and a second data usage record including the second data usage identified with the second service activity; and send the first data usage record and the second data usage record to a network element.

12. The mobile end-user device of claim 11, wherein determining that the first service activity is associated with the first Internet data traffic flow comprises inspecting one or more Internet data packets of the first Internet data traffic flow.

13. The mobile end-user device of claim 12, wherein inspecting the one or more Internet data packets of the first Internet data traffic flow comprises extracting a uniform resource locator (URL) identifier, a referring tag, or a referring header.

14. The mobile end-user device of claim 11, wherein determining that the first service activity is associated with the first Internet data traffic flow comprises detecting a proximity in time between the first Internet data traffic flow and other traffic identified as being associated with the first service activity.

15. The mobile end-user device of claim 11, wherein the one or more processors are further configured to: apply a first traffic control to the first Internet data traffic flow in accordance with a traffic control service policy associated with first service activity.

16. The mobile end-user device of claim 11, wherein the one or more processors are further configured to: provide, a notification through a user interface of the mobile end-user device, indicating whether one or more of the plurality of Internet data traffic flows is associated with at least one of the first service activity or the second service activity.

17. The mobile end-user device of claim 11, wherein the one or more processors are further configured to: block the first Internet data traffic flow based on association with the first service activity.

18. The mobile end-user device of claim 17, wherein the one or more processors are further configured to: provide, a notification through a user interface of the mobile end-user device, indicating that the first Internet data traffic flow was blocked.

19. The mobile end-user device of claim 11, wherein the first service activity is associated with a first application on the mobile end-user device, and the second service activity is associated with a second application on the mobile end-user device.

20. The mobile end-user device of claim 11, wherein the first service activity is associated with an address or a uniform resource locator (URL) with which the mobile end-user device is communicating.