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(54) **ENTERPRISE ACCESS CONTROL AND ACCOUNTING ALLOCATION FOR ACCESS NETWORKS**

(56) **References Cited**

U.S. PATENT DOCUMENTS

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5,131,020 A 7/1992 Liebesny et al.

5,283,904 A 2/1994 Carson et al.

(Continued)

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FOREIGN PATENT DOCUMENTS

CA 2688553 12/2008

CN 1310401 A 2/2000

(Continued)

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OTHER PUBLICATIONS

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(Continued)

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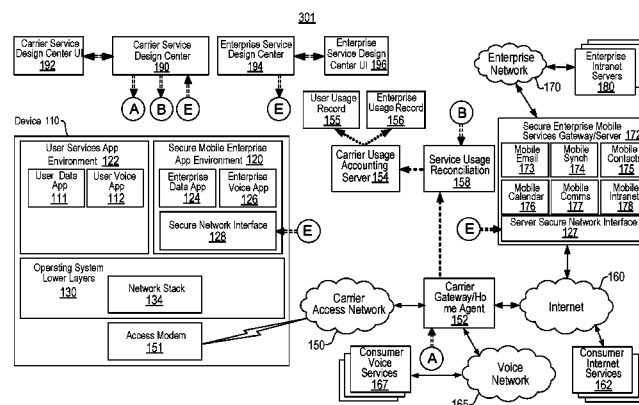
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(57) **ABSTRACT**

Enterprise and consumer billing allocation for wireless communication device service usage activities is provided. In some embodiments, enterprise and consumer billing allocation for wireless communication device service usage activities includes monitoring a service usage activity of a wireless communication device, and determining an enterprise and consumer billing allocation for the monitored service usage activity. In some embodiments, enterprise and consumer billing allocation for wireless communication device service usage activities includes monitoring a service usage activity of a wireless communication device, and reporting the monitored service usage activity to a network element, in which the network element determines an enterprise and consumer billing allocation for the monitored service usage activity. In some embodiments, enterprise and consumer billing allocation for wireless communication device service usage activities includes providing a service design center for configuring an enterprise and consumer

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billing allocation of monitored service usage activities for a plurality of wireless communication devices associated with an enterprise account, and implementing the configured enterprise and consumer billing allocation for monitored service usage activities for the plurality of wireless communication devices associated with the enterprise account.

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See application file for complete search history.

(56) References Cited

U.S. PATENT DOCUMENTS

5,325,532 A 6/1994 Crosswy et al.
 5,572,528 A 11/1996 Shuen
 5,577,100 A 11/1996 McGregor et al.
 5,594,777 A 1/1997 Makkonen et al.
 5,617,539 A 4/1997 Ludwig et al.
 5,630,159 A 5/1997 Zanchi
 5,633,484 A 5/1997 Zanchi et al.
 5,633,868 A 5/1997 Baldwin et al.
 5,754,953 A 5/1998 Briancon et al.
 5,774,532 A 6/1998 Gottlieb et al.
 5,794,142 A 8/1998 Vanttila et al.
 5,814,798 A 9/1998 Zanchi
 5,889,477 A 3/1999 Fastenrath
 5,892,900 A 4/1999 Ginter et al.
 5,903,845 A 5/1999 Buhrmann et al.
 5,915,008 A 6/1999 Dulman
 5,915,226 A 6/1999 Martineau
 5,933,778 A 8/1999 Buhrmann et al.
 5,940,472 A 8/1999 Newman et al.
 5,974,439 A 10/1999 Bollella
 5,983,270 A 11/1999 Abraham et al.
 6,035,281 A 3/2000 Crosskey et al.
 6,038,452 A 3/2000 Strawczynski et al.

6,038,540 A 3/2000 Krist et al.
 6,047,268 A 4/2000 Bartoli et al.
 6,058,434 A 5/2000 Wilt et al.
 6,061,571 A 5/2000 Tamura
 6,064,878 A 5/2000 Denker et al.
 6,078,953 A 6/2000 Vaid et al.
 6,081,591 A 6/2000 Skoog
 6,098,878 A 8/2000 Dent et al.
 6,104,700 A 8/2000 Haddock et al.
 6,115,823 A 9/2000 Velasco et al.
 6,119,933 A 9/2000 Wong et al.
 6,125,391 A 9/2000 Meltzer et al.
 6,141,565 A 10/2000 Feurerstein et al.
 6,141,686 A 10/2000 Jackowski et al.
 6,148,336 A 11/2000 Thomas et al.
 6,154,738 A 11/2000 Call
 6,157,636 A 12/2000 Voit et al.
 6,185,576 B1 2/2001 McIntosh
 6,198,915 B1 3/2001 McGregor et al.
 6,219,786 B1 4/2001 Cunningham et al.
 6,226,277 B1 5/2001 Chuah
 6,246,870 B1 6/2001 Dent et al.
 6,263,055 B1 7/2001 Garland et al.
 6,292,828 B1 9/2001 Williams
 6,317,584 B1 11/2001 Abu-Amara et al.
 6,381,316 B2 4/2002 Joyce et al.
 6,393,014 B1 5/2002 Daly et al.
 6,397,259 B1 5/2002 Lincke et al.
 6,401,113 B2 6/2002 Lazaridis et al.
 6,418,147 B1 7/2002 Wiedeman
 6,438,575 B1 8/2002 Khan et al.
 6,445,777 B1 9/2002 Clark
 6,449,479 B1 9/2002 Sanchez
 6,466,984 B1 10/2002 Naveh et al.
 6,477,670 B1 11/2002 Ahmadvand
 6,502,131 B1 12/2002 Vaid et al.
 6,505,114 B2 1/2003 Luciani
 6,510,152 B1 1/2003 Gerszberg et al.
 6,522,629 B1 2/2003 Anderson, Sr.
 6,532,235 B1 3/2003 Benson et al.
 6,532,579 B2 3/2003 Sato et al.
 6,535,855 B1 3/2003 Cahill et al.
 6,535,949 B1 3/2003 Parker
 6,539,082 B1 3/2003 Lowe et al.
 6,542,500 B1 4/2003 Gerszberg et al.
 6,542,992 B1 4/2003 Peirce et al.
 6,546,016 B1 4/2003 Gerszberg et al.
 6,563,806 B1 5/2003 Yano et al.
 6,570,974 B1 5/2003 Gerszberg et al.
 6,574,321 B1 6/2003 Cox et al.
 6,574,465 B2 6/2003 Marsh et al.
 6,578,076 B1 6/2003 Putzolu
 6,581,092 B1 6/2003 Motoyama
 6,591,098 B1 7/2003 Shieh et al.
 6,598,034 B1 7/2003 Kloth
 6,601,040 B1 7/2003 Kolls
 6,603,969 B1 8/2003 Vuoristo et al.
 6,603,975 B1 8/2003 Inouchi et al.
 6,606,744 B1 8/2003 Mikurak
 6,628,934 B2 9/2003 Rosenberg et al.
 6,631,122 B1 10/2003 Arunachalam et al.
 6,636,721 B2 10/2003 Threadgill et al.
 6,639,975 B1 10/2003 O'Neal et al.
 6,640,097 B2 10/2003 Corrigan et al.
 6,640,334 B1 10/2003 Rasmussen
 6,650,887 B2 11/2003 McGregor et al.
 6,651,101 B1 11/2003 Gai et al.
 6,654,786 B1 11/2003 Fox et al.
 6,654,814 B1 11/2003 Britton et al.
 6,658,254 B1 12/2003 Purdy et al.
 6,662,014 B1 12/2003 Walsh
 6,678,516 B2 1/2004 Nordman et al.
 6,683,853 B1 1/2004 Kannas et al.
 6,684,244 B1 1/2004 Goldman et al.
 6,690,918 B2 2/2004 Evans et al.
 6,697,821 B2 2/2004 Ziff et al.
 6,725,031 B2 4/2004 Watler et al.
 6,725,256 B1 4/2004 Albal et al.
 6,735,206 B1 5/2004 Oki et al.

(56)

References Cited

U.S. PATENT DOCUMENTS

6,748,195 B1	6/2004	Phillips	7,133,386 B2	11/2006	Holur et al.
6,748,437 B1	6/2004	Mankude et al.	7,133,695 B2	11/2006	Beyda
6,751,296 B1	6/2004	Albal et al.	7,136,361 B2	11/2006	Benveniste
6,754,470 B2	6/2004	Hendrickson et al.	7,139,569 B2	11/2006	Kato
6,757,717 B1	6/2004	Goldstein	7,142,876 B2	11/2006	Trossen et al.
6,760,417 B1	7/2004	Wallenius	7,149,229 B1	12/2006	Leung
6,763,000 B1	7/2004	Walsh	7,149,521 B2	12/2006	Sundar et al.
6,763,226 B1	7/2004	McZeal, Jr.	7,151,764 B1	12/2006	Heinonen et al.
6,765,864 B1	7/2004	Natarajan et al.	7,158,792 B1	1/2007	Cook et al.
6,765,925 B1	7/2004	Sawyer et al.	7,162,237 B1	1/2007	Silver et al.
6,782,412 B2	8/2004	Brophy et al.	7,165,040 B2	1/2007	Ehrman et al.
6,785,889 B1	8/2004	Williams	7,167,078 B2	1/2007	Pourchot
6,792,461 B1	9/2004	Hericourt	7,174,156 B1	2/2007	Mangal
6,829,596 B1	12/2004	Frazee	7,174,174 B2	2/2007	Boris et al.
6,829,696 B1	12/2004	Balmer et al.	7,177,919 B1	2/2007	Truong et al.
6,839,340 B1	1/2005	Voit et al.	7,180,855 B1	2/2007	Lin
6,873,988 B2	3/2005	Herrmann et al.	7,181,017 B1	2/2007	Nagel et al.
6,876,653 B2	4/2005	Ambe et al.	7,191,248 B2	3/2007	Chattopadhyay et al.
6,879,825 B1	4/2005	Daly	7,197,321 B2	3/2007	Erskine et al.
6,882,718 B1	4/2005	Smith	7,200,112 B2	4/2007	Sundar et al.
6,885,997 B1	4/2005	Roberts	7,203,169 B1	4/2007	Okholm et al.
6,901,440 B1	5/2005	Bimm et al.	7,203,721 B1	4/2007	Ben-Efraim et al.
6,920,455 B1	7/2005	Weschler	7,203,752 B2	4/2007	Rice et al.
6,922,562 B2	7/2005	Ward et al.	7,212,491 B2	5/2007	Koga
6,928,280 B1	8/2005	Xanthos et al.	7,219,123 B1	5/2007	Fiechter et al.
6,934,249 B1	8/2005	Bertin et al.	7,222,190 B2	5/2007	Klinker et al.
6,934,751 B2	8/2005	Jayapalan et al.	7,222,304 B2	5/2007	Beaton et al.
6,947,723 B1	9/2005	Gurnani et al.	7,224,968 B2	5/2007	Dobson et al.
6,947,985 B2	9/2005	Hegli et al.	7,228,354 B2	6/2007	Chambliss et al.
6,952,428 B1	10/2005	Necka et al.	7,236,780 B2	6/2007	Benco
6,957,067 B1	10/2005	Iyer et al.	7,242,668 B2	7/2007	Kan et al.
6,959,202 B2	10/2005	Heinonen et al.	7,242,920 B2	7/2007	Morris
6,959,393 B2	10/2005	Hollis et al.	7,245,901 B2	7/2007	McGregor et al.
6,965,667 B2	11/2005	Trabandt et al.	7,248,570 B2	7/2007	Bahl et al.
6,965,872 B1	11/2005	Grdina	7,251,218 B2	7/2007	Jorgensen
6,967,958 B2	11/2005	Ono et al.	7,260,382 B1	8/2007	Lamb et al.
6,970,692 B2	11/2005	Tysor	7,266,371 B1	9/2007	Amin et al.
6,982,733 B1	1/2006	McNally et al.	7,269,157 B2	9/2007	Klinker et al.
6,983,370 B2	1/2006	Eaton et al.	7,271,765 B2	9/2007	Stilp et al.
6,996,062 B1	2/2006	Freed et al.	7,272,660 B1	9/2007	Powers et al.
6,996,076 B1	2/2006	Forbes et al.	7,280,816 B2	10/2007	Fratti et al.
6,996,393 B2	2/2006	Pyhalammii et al.	7,280,818 B2	10/2007	Clayton
6,998,985 B2	2/2006	Reisman et al.	7,283,561 B1	10/2007	Picher-Dempsey
7,002,920 B1	2/2006	Ayyagari et al.	7,283,963 B1	10/2007	Fitzpatrick et al.
7,007,295 B1	2/2006	Rose et al.	7,286,834 B2	10/2007	Walter
7,013,469 B2	3/2006	Smith et al.	7,286,848 B2	10/2007	Vireday et al.
7,017,189 B1	3/2006	DeMello et al.	7,289,489 B1	10/2007	Kung et al.
7,024,200 B2	4/2006	McKenna et al.	7,290,283 B2	10/2007	Copeland, III
7,024,460 B2	4/2006	Koopmas et al.	7,310,424 B2	12/2007	Gehring et al.
7,027,055 B2	4/2006	Anderson et al.	7,313,237 B2	12/2007	Bahl et al.
7,027,408 B2	4/2006	Nabkel et al.	7,315,892 B2	1/2008	Freimuth et al.
7,031,733 B2	4/2006	Alminana et al.	7,317,699 B2	1/2008	Godfrey et al.
7,032,072 B1	4/2006	Quinn et al.	7,318,111 B2	1/2008	Zhao
7,039,027 B2	5/2006	Bridgelall	7,320,029 B2	1/2008	Rinne et al.
7,039,037 B2	5/2006	Wang et al.	7,322,044 B2	1/2008	Hrastar
7,039,403 B2	5/2006	Wong	7,324,447 B1	1/2008	Morford
7,039,713 B1	5/2006	Van Gunter et al.	7,325,037 B2	1/2008	Lawson
7,042,988 B2	5/2006	Juitt et al.	7,336,960 B2	2/2008	Zavalkovsky et al.
7,043,225 B1	5/2006	Patel et al.	7,340,772 B2	3/2008	Panasyuk et al.
7,043,226 B2	5/2006	Yamauchi	7,346,410 B2	3/2008	Uchiyama
7,043,268 B2	5/2006	Yukie et al.	7,349,695 B2	3/2008	Oommen et al.
7,047,276 B2	5/2006	Liu et al.	7,353,533 B2	4/2008	Wright et al.
7,058,022 B1	6/2006	Carolan et al.	7,356,011 B1	4/2008	Waters et al.
7,058,968 B2	6/2006	Rowland et al.	7,356,337 B2	4/2008	Florence
7,068,600 B2	6/2006	Cain	7,366,497 B2	4/2008	Nagata
7,069,248 B2	6/2006	Huber	7,366,654 B2	4/2008	Moore
7,082,422 B1	7/2006	Zirngibl et al.	7,369,848 B2	5/2008	Jiang
7,084,775 B1	8/2006	Smith	7,369,856 B2	5/2008	Ovadia
7,092,696 B1	8/2006	Hosain et al.	7,373,136 B2	5/2008	Watler et al.
7,095,754 B2	8/2006	Benveniste	7,373,179 B2	5/2008	Stine et al.
7,102,620 B2	9/2006	Harries et al.	7,379,731 B2	5/2008	Natsuno et al.
7,110,753 B2	9/2006	Campen	7,388,950 B2	6/2008	Elsey et al.
7,113,780 B2	9/2006	McKenna et al.	7,389,412 B2	6/2008	Sharma et al.
7,113,997 B2	9/2006	Jayapalan et al.	7,391,724 B2	6/2008	Alakoski et al.
7,120,133 B1	10/2006	Joo et al.	7,395,244 B1	7/2008	Kingsford
			7,401,338 B1	7/2008	Bowen et al.
			7,403,763 B2	7/2008	Maes
			7,409,447 B1	8/2008	Assadzadeh
			7,409,569 B2	8/2008	Illowsky et al.

(56)

References Cited

U.S. PATENT DOCUMENTS

7,411,930	B2	8/2008	Montejo et al.	7,620,162	B2	11/2009	Aaron et al.
7,418,253	B2	8/2008	Kavanah	7,620,383	B2	11/2009	Taglienti et al.
7,418,257	B2	8/2008	Kim	7,627,314	B2	12/2009	Carlson et al.
7,421,004	B2	9/2008	Feher	7,627,600	B2	12/2009	Citron et al.
7,423,971	B1	9/2008	Mohaban et al.	7,627,767	B2	12/2009	Sherman et al.
7,428,750	B1	9/2008	Dunn et al.	7,627,872	B2	12/2009	Hebeler et al.
7,440,433	B2	10/2008	Rink et al.	7,633,438	B2	12/2009	Tysowski
7,444,669	B1	10/2008	Bahl et al.	7,634,388	B2	12/2009	Archer et al.
7,450,591	B2	11/2008	Korling et al.	7,636,574	B2	12/2009	Poosala
7,450,927	B1	11/2008	Creswell et al.	7,636,626	B2	12/2009	Oesterling et al.
7,454,191	B2	11/2008	Dawson et al.	7,643,411	B2	1/2010	Andreasen et al.
7,457,265	B2	11/2008	Julka et al.	7,644,151	B2	1/2010	Jerrim et al.
7,457,870	B1	11/2008	Lownsbrough et al.	7,644,267	B2	1/2010	Ylikoski et al.
7,460,837	B2	12/2008	Diener	7,647,047	B2	1/2010	Moghaddam et al.
7,466,652	B2	12/2008	Lau et al.	7,650,137	B2	1/2010	Jobs et al.
7,472,189	B2	12/2008	Mallya et al.	7,653,394	B2	1/2010	McMillin
7,478,420	B2	1/2009	Wright et al.	7,656,271	B2	2/2010	Ehrman et al.
7,486,185	B2	2/2009	Culpepper et al.	7,657,920	B2	2/2010	Arseneau et al.
7,486,658	B2	2/2009	Kumar	7,660,419	B1	2/2010	Ho
7,493,659	B1	2/2009	Wu et al.	7,661,124	B2	2/2010	Ramanathan et al.
7,496,652	B2	2/2009	Pezzutti	7,664,494	B2	2/2010	Jiang
7,499,438	B2	3/2009	Hinman et al.	7,668,176	B2	2/2010	Chuah
7,499,537	B2	3/2009	Elsey et al.	7,668,612	B1	2/2010	Okkonen
7,502,672	B1	3/2009	Kolls	7,668,903	B2	2/2010	Edwards et al.
7,505,795	B1	3/2009	Lim et al.	7,668,966	B2	2/2010	Klinker et al.
7,508,799	B2	3/2009	Sumner et al.	7,676,673	B2	3/2010	Weller et al.
7,512,128	B2	3/2009	DiMambro et al.	7,680,086	B2	3/2010	Eglin
7,512,131	B2	3/2009	Svensson et al.	7,681,226	B2	3/2010	Kraemer et al.
7,515,608	B2	4/2009	Yuan et al.	7,684,370	B2	3/2010	Kezys
7,515,926	B2	4/2009	Bu et al.	7,685,131	B2	3/2010	Batra et al.
7,516,219	B2	4/2009	Moghaddam et al.	7,685,254	B2	3/2010	Pandya
7,522,576	B2	4/2009	Du et al.	7,685,530	B2	3/2010	Sherrard et al.
7,526,541	B2	4/2009	Roose et al.	7,688,792	B2	3/2010	Babbar et al.
7,529,204	B2	5/2009	Bourlas et al.	7,693,107	B2	4/2010	De Froment
7,535,880	B1	5/2009	Hinman et al.	7,693,720	B2	4/2010	Kennewick et al.
7,536,695	B2	5/2009	Alam et al.	7,697,540	B2	4/2010	Haddad et al.
7,539,132	B2	5/2009	Werner et al.	7,710,932	B2	5/2010	Muthuswamy et al.
7,539,862	B2	5/2009	Edgett et al.	7,711,848	B2	5/2010	Maes
7,540,408	B2	6/2009	Levine et al.	7,719,966	B2	5/2010	Luft et al.
7,545,782	B2	6/2009	Rayment et al.	7,720,206	B2	5/2010	Devolites et al.
7,546,460	B2	6/2009	Maes	7,720,464	B2	5/2010	Batta
7,546,629	B2	6/2009	Albert et al.	7,720,505	B2	5/2010	Gopi et al.
7,548,875	B2	6/2009	Mikkelsen et al.	7,720,960	B2	5/2010	Pruss et al.
7,548,976	B2	6/2009	Bahl et al.	7,721,296	B2	5/2010	Ricagni
7,551,922	B2	6/2009	Roskowski et al.	7,724,716	B2	5/2010	Fadell
7,554,983	B1	6/2009	Muppala	7,725,570	B1	5/2010	Lewis
7,555,757	B2	6/2009	Smith et al.	7,729,326	B2	6/2010	Sekhar
7,561,899	B2	7/2009	Lee	7,730,123	B1	6/2010	Erickson et al.
7,562,213	B1	7/2009	Timms	7,734,784	B1	6/2010	Araujo et al.
7,564,799	B2	7/2009	Holland et al.	7,742,406	B1	6/2010	Muppala
7,565,141	B2	7/2009	Macaluso	7,746,854	B2	6/2010	Ambe et al.
7,574,509	B2	8/2009	Nixon et al.	7,747,240	B1	6/2010	Briscoe et al.
7,574,731	B2	8/2009	Fascenda	7,747,699	B2	6/2010	Prueitt et al.
7,577,431	B2	8/2009	Jiang	7,747,730	B1	6/2010	Harlow
7,580,356	B1	8/2009	Mishra et al.	7,752,330	B2	7/2010	Olsen et al.
7,580,857	B2	8/2009	VanFleet et al.	7,756,056	B2	7/2010	Kim et al.
7,583,964	B2	9/2009	Wong	7,756,534	B2	7/2010	Anupam et al.
7,584,298	B2	9/2009	Klinker et al.	7,756,757	B1	7/2010	Oakes, III
7,586,871	B2	9/2009	Hamilton et al.	7,760,137	B2	7/2010	Martucci et al.
7,593,417	B2	9/2009	Wang et al.	7,760,711	B1	7/2010	Kung et al.
7,593,730	B2	9/2009	Khandelwal et al.	7,760,861	B1	7/2010	Croak et al.
7,599,288	B2	10/2009	Cole et al.	7,765,294	B2	7/2010	Edwards et al.
7,599,714	B2	10/2009	Kuzminskiy	7,769,397	B2	8/2010	Funato et al.
7,602,746	B2	10/2009	Calhoun et al.	7,770,785	B2	8/2010	Jha et al.
7,607,041	B2	10/2009	Kraemer et al.	7,774,323	B2	8/2010	Helfman
7,609,650	B2	10/2009	Roskowski et al.	7,774,412	B1	8/2010	Schnepel
7,609,700	B1	10/2009	Ying et al.	7,774,456	B1	8/2010	Lownsbrough et al.
7,610,047	B2	10/2009	Hicks, III et al.	7,778,176	B2	8/2010	Morford
7,610,057	B2	10/2009	Bahl et al.	7,778,643	B2	8/2010	Laroia et al.
7,610,328	B2	10/2009	Haase et al.	7,792,257	B1	9/2010	Vanier et al.
7,610,396	B2	10/2009	Taglienti et al.	7,792,538	B2	9/2010	Kozisek
7,614,051	B2	11/2009	Glaum et al.	7,792,708	B2	9/2010	Alva
7,617,516	B2	11/2009	Huslak et al.	7,797,019	B2	9/2010	Friedmann
7,620,041	B2	11/2009	Dunn et al.	7,797,060	B2	9/2010	Grgic et al.
7,620,065	B2	11/2009	Falardeau	7,797,204	B2	9/2010	Balent
				7,797,401	B2	9/2010	Stewart et al.
				7,801,523	B1	9/2010	Kenderov
				7,801,783	B2	9/2010	Kende et al.
				7,801,985	B1	9/2010	Pitkow et al.

(56)

References Cited

U.S. PATENT DOCUMENTS

7,802,724	B1	9/2010	Nohr	7,953,808	B2	5/2011	Sharp et al.
7,805,140	B2	9/2010	Friday et al.	7,953,877	B2	5/2011	Vemula et al.
7,805,522	B2	9/2010	Schlüter et al.	7,957,020	B2	6/2011	Mine et al.
7,805,606	B2	9/2010	Birger et al.	7,957,381	B2	6/2011	Clermidy et al.
7,809,351	B1	10/2010	Panda et al.	7,957,511	B2	6/2011	Drudis et al.
7,809,372	B2	10/2010	Rajaniemi	7,958,029	B1	6/2011	Bobich et al.
7,813,746	B2	10/2010	Rajkotia	7,962,622	B2	6/2011	Friend et al.
7,817,615	B1	10/2010	Breau et al.	7,965,983	B1	6/2011	Swan et al.
7,817,983	B2	10/2010	Cassett et al.	7,966,405	B2	6/2011	Sundaresan et al.
7,822,837	B1	10/2010	Urban et al.	7,969,950	B2	6/2011	Iyer et al.
7,826,427	B2	11/2010	Sood et al.	7,970,350	B2	6/2011	Sheynman
7,826,607	B1	11/2010	de Carvalho Resende et al.	7,970,426	B2	6/2011	Poe et al.
7,835,275	B1	11/2010	Swan et al.	7,974,624	B2	7/2011	Gallagher et al.
7,843,831	B2	11/2010	Morrill et al.	7,975,184	B2	7/2011	Goff et al.
7,843,843	B1	11/2010	Papp, III et al.	7,978,627	B2	7/2011	Taylor et al.
7,844,034	B1	11/2010	Oh et al.	7,978,686	B2	7/2011	Goyal et al.
7,844,728	B2	11/2010	Anderson et al.	7,979,069	B2	7/2011	Hupp et al.
7,848,768	B2	12/2010	Omori et al.	7,979,889	B2	7/2011	Gladstone et al.
7,849,161	B2	12/2010	Koch et al.	7,984,130	B2	7/2011	Bogineni et al.
7,849,477	B2	12/2010	Cristofalo et al.	7,984,511	B2	7/2011	Kocher et al.
7,853,255	B2	12/2010	Karaoguz et al.	7,986,935	B1	7/2011	D'Souza et al.
7,853,656	B2	12/2010	Yach et al.	7,987,496	B2	7/2011	Bryce et al.
7,856,226	B2	12/2010	Wong et al.	7,987,510	B2	7/2011	Kocher et al.
7,860,088	B2	12/2010	Lioy	7,990,049	B2	8/2011	Shioya
7,865,182	B2	1/2011	Macaluso	8,000,276	B2	8/2011	Scherzer et al.
7,865,187	B2	1/2011	Ramer et al.	8,000,318	B2	8/2011	Wiley et al.
7,868,778	B2	1/2011	Kenwright	8,005,009	B2	8/2011	McKee et al.
7,873,001	B2	1/2011	Silver	8,005,459	B2	8/2011	Balsillie
7,873,344	B2	1/2011	Bowser et al.	8,005,726	B1	8/2011	Bao
7,873,346	B2	1/2011	Petersson et al.	8,005,913	B1	8/2011	Carlander
7,873,540	B2	1/2011	Arumugam	8,005,988	B2	8/2011	Maes
7,873,705	B2	1/2011	Kalish	8,010,080	B1	8/2011	Thenthiruperai et al.
7,877,090	B2	1/2011	Maes	8,010,081	B1	8/2011	Roskowski
7,881,199	B2	2/2011	Krstulich	8,010,082	B2	8/2011	Sutaria et al.
7,881,697	B2	2/2011	Baker et al.	8,010,990	B2	8/2011	Ferguson et al.
7,882,029	B2	2/2011	White	8,015,133	B1	9/2011	Wu et al.
7,882,247	B2	2/2011	Sturniolo et al.	8,015,234	B2	9/2011	Lum et al.
7,882,560	B2	2/2011	Kraemer et al.	8,019,687	B2	9/2011	Wang et al.
7,886,047	B1	2/2011	Potluri	8,019,820	B2	9/2011	Son et al.
7,889,384	B2	2/2011	Armentrout et al.	8,019,846	B2	9/2011	Roelens et al.
7,890,084	B1	2/2011	Dudziak et al.	8,019,868	B2	9/2011	Rao et al.
7,890,111	B2	2/2011	Bugenhagen	8,019,886	B2	9/2011	Harrang et al.
7,894,431	B2	2/2011	Goring et al.	8,023,425	B2	9/2011	Raleigh
7,899,039	B2	3/2011	Andreasen et al.	8,024,397	B1	9/2011	Erickson et al.
7,899,438	B2	3/2011	Baker et al.	8,024,424	B2	9/2011	Freimuth et al.
7,903,553	B2	3/2011	Liu	8,027,339	B2	9/2011	Short et al.
7,907,970	B2	3/2011	Park et al.	8,031,601	B2	10/2011	Feroz et al.
7,911,975	B2	3/2011	Droz et al.	8,032,168	B2	10/2011	Ikaheimo
7,912,025	B2	3/2011	Pattenden et al.	8,032,409	B1	10/2011	Mikurak
7,912,056	B1	3/2011	Brassem	8,032,899	B2	10/2011	Archer et al.
7,920,529	B1	4/2011	Mahler et al.	8,036,387	B2	10/2011	Kudelski et al.
7,921,463	B2	4/2011	Sood et al.	8,036,600	B2	10/2011	Garrett et al.
7,925,740	B2	4/2011	Nath et al.	8,044,792	B2	10/2011	Orr et al.
7,925,778	B1	4/2011	Wijnands et al.	8,045,973	B2	10/2011	Chambers
7,929,959	B2	4/2011	DeAtley et al.	8,046,449	B2	10/2011	Yoshiuchi
7,929,960	B2	4/2011	Martin et al.	8,050,275	B1	11/2011	Iyer
7,929,973	B2	4/2011	Zavalkovsky et al.	8,050,690	B2	11/2011	Neeraj
7,930,327	B2	4/2011	Craft et al.	8,050,705	B2	11/2011	Sicher et al.
7,930,446	B2	4/2011	Kesselman et al.	8,059,530	B1	11/2011	Cole
7,930,553	B2	4/2011	Satarasinghe et al.	8,060,017	B2	11/2011	Schlicht et al.
7,933,274	B2	4/2011	Verma et al.	8,060,463	B1	11/2011	Spiegel
7,936,736	B2	5/2011	Proctor, Jr. et al.	8,064,418	B2	11/2011	Maki
7,937,069	B2	5/2011	Rassam	8,064,896	B2	11/2011	Bell et al.
7,937,450	B2	5/2011	Janik	8,065,365	B2	11/2011	Saxena et al.
7,940,685	B1	5/2011	Breslau et al.	8,068,824	B2	11/2011	Shan et al.
7,940,751	B2	5/2011	Hansen	8,068,829	B2	11/2011	Lemond et al.
7,941,184	B2	5/2011	Prendergast et al.	8,073,427	B2	12/2011	Koch et al.
7,944,948	B2	5/2011	Chow et al.	8,073,721	B1	12/2011	Lewis
7,945,238	B2	5/2011	Baker et al.	8,078,140	B2	12/2011	Baker et al.
7,945,240	B1	5/2011	Klock et al.	8,078,163	B2	12/2011	Lemond et al.
7,945,945	B2	5/2011	Graham et al.	8,085,808	B2	12/2011	Brusca et al.
7,948,952	B2	5/2011	Hurtta et al.	8,086,398	B2	12/2011	Sanchez et al.
7,948,953	B2	5/2011	Melkote et al.	8,086,497	B1	12/2011	Oakes, III
7,948,968	B2	5/2011	Voit et al.	8,086,791	B2	12/2011	Caulkins
7,949,529	B2	5/2011	Weider et al.	8,090,359	B2	1/2012	Proctor, Jr. et al.
				8,090,361	B2	1/2012	Hagan
				8,090,616	B2	1/2012	Proctor, Jr. et al.
				8,091,087	B2	1/2012	Ali et al.
				8,094,551	B2	1/2012	Huber et al.

(56)

References Cited

U.S. PATENT DOCUMENTS

8,095,112 B2	1/2012	Chow et al.	8,194,553 B2	6/2012	Liang et al.
8,095,124 B2	1/2012	Balia	8,194,572 B2	6/2012	Horvath et al.
8,095,640 B2	1/2012	Guingo et al.	8,194,581 B1	6/2012	Schroeder et al.
8,095,666 B2	1/2012	Schmidt et al.	8,195,093 B2	6/2012	Garrett et al.
8,098,579 B2	1/2012	Ray et al.	8,195,153 B1	6/2012	Frencel et al.
8,099,077 B2	1/2012	Chowdhury et al.	8,195,163 B2	6/2012	Gisby et al.
8,099,517 B2	1/2012	Jia et al.	8,195,661 B2	6/2012	Kalavade
8,102,814 B2	1/2012	Rahman et al.	8,196,199 B2	6/2012	Hrastar et al.
8,103,285 B2	1/2012	Kalhan	8,200,163 B2	6/2012	Hoffman
8,104,080 B2	1/2012	Burns et al.	8,200,200 B1	6/2012	Belser et al.
8,107,953 B2	1/2012	Zimmerman et al.	8,200,509 B2	6/2012	Kenedy et al.
8,108,520 B2	1/2012	Ruutu et al.	8,200,775 B2	6/2012	Moore
8,112,435 B2	2/2012	Epstein et al.	8,200,818 B2	6/2012	Freund et al.
8,116,223 B2	2/2012	Tian et al.	8,204,190 B2	6/2012	Bang et al.
8,116,749 B2	2/2012	Proctor, Jr. et al.	8,204,505 B2	6/2012	Jin et al.
8,116,781 B2	2/2012	Chen et al.	8,204,794 B1	6/2012	Peng et al.
8,122,128 B2	2/2012	Burke, II et al.	8,208,788 B2	6/2012	Ando et al.
8,122,249 B2	2/2012	Falk et al.	8,208,919 B2	6/2012	Kotecha
8,125,897 B2	2/2012	Ray et al.	8,213,296 B2	7/2012	Shannon et al.
8,126,123 B2	2/2012	Cai et al.	8,213,363 B2	7/2012	Ying et al.
8,126,396 B2	2/2012	Bennett	8,214,536 B2	7/2012	Zhao
8,126,476 B2	2/2012	Vardi et al.	8,214,890 B2	7/2012	Kirovski et al.
8,126,722 B2	2/2012	Robb et al.	8,219,134 B2	7/2012	Maharajh et al.
8,130,793 B2	3/2012	Edwards et al.	8,223,655 B2	7/2012	Heinz et al.
8,131,256 B2	3/2012	Martti et al.	8,223,741 B1	7/2012	Bartlett et al.
8,131,281 B1	3/2012	Hildner et al.	8,224,382 B2	7/2012	Bultman
8,131,840 B1	3/2012	Denker	8,224,773 B2	7/2012	Spiegel
8,131,858 B2	3/2012	Agulnik et al.	8,228,818 B2	7/2012	Chase et al.
8,132,256 B2	3/2012	Bari	8,229,394 B2	7/2012	Karlberg
8,134,954 B2	3/2012	Godfrey et al.	8,229,914 B2	7/2012	Ramer et al.
8,135,388 B1	3/2012	Gailloux et al.	8,230,061 B2	7/2012	Hassan et al.
8,135,392 B2	3/2012	Marcellino et al.	8,233,433 B2	7/2012	Kalhan
8,135,657 B2	3/2012	Kapoor et al.	8,233,883 B2	7/2012	De Froment
8,140,690 B2	3/2012	Ly et al.	8,233,895 B2	7/2012	Tysowski
8,144,591 B2	3/2012	Ghai et al.	8,234,583 B2	7/2012	Sloo et al.
8,145,194 B2	3/2012	Yoshikawa et al.	8,238,287 B1	8/2012	Gopi et al.
8,146,142 B2	3/2012	Lortz et al.	8,239,520 B2	8/2012	Grah
8,149,748 B2	4/2012	Bata et al.	8,242,959 B2	8/2012	Mia et al.
8,149,823 B2	4/2012	Turcan et al.	8,244,241 B2	8/2012	Montemurro
8,150,394 B2	4/2012	Bianconi et al.	8,249,601 B2	8/2012	Emberson et al.
8,150,431 B2	4/2012	Wolovitz et al.	8,254,880 B2	8/2012	Aaltonen et al.
8,151,205 B2	4/2012	Follmann et al.	8,254,915 B2	8/2012	Kozisek
8,155,155 B1	4/2012	Chow et al.	8,255,515 B1	8/2012	Melman et al.
8,155,620 B2	4/2012	Wang et al.	8,255,534 B2	8/2012	Assadzadeh
8,155,666 B2	4/2012	Alizadeh-Shabdiz	8,255,689 B2	8/2012	Kim et al.
8,155,670 B2	4/2012	Fullam et al.	8,259,692 B2	9/2012	Bajko
8,156,206 B2	4/2012	Kiley et al.	8,264,965 B2	9/2012	Dolganow et al.
8,159,520 B1	4/2012	Dhanoa et al.	8,265,004 B2	9/2012	Toutonghi
8,160,015 B2	4/2012	Rashid et al.	8,266,681 B2	9/2012	Deshpande et al.
8,160,056 B2	4/2012	Van der Merwe et al.	8,270,955 B2	9/2012	Ramer et al.
8,160,598 B2	4/2012	Savoor	8,270,972 B2	9/2012	Otting et al.
8,165,576 B2	4/2012	Raju et al.	8,271,025 B2	9/2012	Brisebois et al.
8,166,040 B2	4/2012	Brindisi et al.	8,271,045 B2	9/2012	Parolkar et al.
8,166,554 B2	4/2012	John	8,271,049 B2	9/2012	Silver et al.
8,170,553 B2	5/2012	Bennett	8,271,992 B2	9/2012	Chatley et al.
8,174,378 B2	5/2012	Richman et al.	8,275,415 B2	9/2012	Huslak
8,174,970 B2	5/2012	Adameczyk et al.	8,275,830 B2	9/2012	Raleigh
8,175,574 B1	5/2012	Panda et al.	8,279,067 B2	10/2012	Berger et al.
8,180,333 B1	5/2012	Wells et al.	8,279,864 B2	10/2012	Wood
8,180,881 B2	5/2012	Seo et al.	8,280,351 B1	10/2012	Ahmed et al.
8,180,886 B2	5/2012	Overcash et al.	8,280,354 B2	10/2012	Smith et al.
8,184,530 B1	5/2012	Swan et al.	8,284,740 B2	10/2012	O'Connor
8,184,590 B2	5/2012	Rosenblatt	8,285,249 B2	10/2012	Baker et al.
8,185,088 B2	5/2012	Klein et al.	8,285,992 B2	10/2012	Mathur et al.
8,185,093 B2	5/2012	Jheng et al.	8,291,238 B2	10/2012	Ginter et al.
8,185,127 B1	5/2012	Cai et al.	8,291,439 B2	10/2012	Jethi et al.
8,185,152 B1	5/2012	Goldner	8,296,404 B2	10/2012	McDysan et al.
8,185,158 B2	5/2012	Tamura et al.	8,300,575 B2	10/2012	Willars
8,190,087 B2	5/2012	Fisher et al.	8,301,513 B1	10/2012	Peng et al.
8,190,122 B1	5/2012	Alexander et al.	8,306,518 B1	11/2012	Gailloux
8,190,675 B2	5/2012	Tribbett	8,306,741 B2	11/2012	Tu
8,191,106 B2	5/2012	Choyi et al.	8,307,067 B2	11/2012	Ryan
8,191,116 B1	5/2012	Gazzard	8,307,095 B2	11/2012	Clark et al.
8,191,124 B2	5/2012	Wynn et al.	8,315,198 B2	11/2012	Corneille et al.
8,194,549 B2	6/2012	Huber et al.	8,315,593 B2	11/2012	Gallant et al.
			8,315,594 B1	11/2012	Mausser et al.
			8,315,718 B2	11/2012	Caffrey et al.
			8,315,999 B2	11/2012	Chatley et al.
			8,320,244 B2	11/2012	Muqattash et al.

(56)

References Cited

U.S. PATENT DOCUMENTS

8,320,902 B2	11/2012	Moring et al.	8,442,015 B2	5/2013	Behzad et al.
8,320,949 B2	11/2012	Matta	8,446,831 B2	5/2013	Kwan et al.
8,325,638 B2	12/2012	Jin et al.	8,447,324 B2	5/2013	Shuman et al.
8,325,906 B2	12/2012	Fullarton et al.	8,447,607 B2	5/2013	Weider et al.
8,326,319 B2	12/2012	Davis	8,447,980 B2	5/2013	Godfrey et al.
8,326,359 B2	12/2012	Kauffman	8,448,015 B2	5/2013	Gerhart
8,326,828 B2	12/2012	Zhou et al.	8,452,858 B2	5/2013	Wu et al.
8,331,223 B2	12/2012	Hill et al.	8,461,958 B2	6/2013	Saenz et al.
8,331,293 B2	12/2012	Sood	8,463,232 B2	6/2013	Tuli et al.
8,332,375 B2	12/2012	Chatley et al.	8,468,337 B2	6/2013	Gaur et al.
8,332,517 B2	12/2012	Russell	8,472,371 B1	6/2013	Bari et al.
8,335,161 B2	12/2012	Footit et al.	8,477,778 B2	7/2013	Lehmann, Jr. et al.
8,339,991 B2	12/2012	Biswas et al.	8,483,135 B2	7/2013	Cai et al.
8,340,625 B1	12/2012	Johnson et al.	8,483,694 B2	7/2013	Lewis et al.
8,340,628 B2	12/2012	Taylor et al.	8,484,327 B2	7/2013	Werner et al.
8,340,678 B1	12/2012	Pandey	8,484,568 B2	7/2013	Rados et al.
8,340,718 B2	12/2012	Colonna et al.	8,488,597 B2	7/2013	Nie et al.
8,346,210 B2	1/2013	Balsan et al.	8,489,110 B2	7/2013	Frank et al.
8,346,923 B2	1/2013	Rowles et al.	8,489,720 B1	7/2013	Morford et al.
8,347,104 B2	1/2013	Pathiyal	8,494,559 B1	7/2013	Malmi
8,347,362 B2	1/2013	Cai et al.	8,495,181 B2	7/2013	Venkatraman et al.
8,347,378 B2	1/2013	Merkin et al.	8,495,227 B2	7/2013	Kaminsky et al.
8,350,700 B2	1/2013	Fast et al.	8,495,360 B2	7/2013	Falk et al.
8,351,592 B2	1/2013	Freeny, Jr. et al.	8,495,700 B2	7/2013	Shahbazi
8,351,898 B2	1/2013	Raleigh	8,495,743 B2	7/2013	Kraemer et al.
8,352,360 B2	1/2013	De Judicibus et al.	8,499,087 B2	7/2013	Hu
8,352,630 B2	1/2013	Hart	8,571,598 B2	7/2013	Valavi
8,352,980 B2	1/2013	Howcroft	RE44,412 E	8/2013	Naqvi et al.
8,353,001 B2	1/2013	Herrod	8,503,358 B2	8/2013	Hanson et al.
8,355,570 B2	1/2013	Karsanbhai et al.	8,503,455 B2	8/2013	Heikens
8,355,696 B1	1/2013	Olding et al.	8,504,032 B2	8/2013	Lott et al.
8,356,336 B2	1/2013	Johnston et al.	8,504,574 B2	8/2013	Dvorak et al.
8,358,638 B2	1/2013	Scherzer et al.	8,504,687 B2	8/2013	Maffione et al.
8,358,975 B2	1/2013	Bahl et al.	8,504,690 B2	8/2013	Shah et al.
8,363,658 B1	1/2013	Delker et al.	8,504,729 B2	8/2013	Pezzutti
8,363,799 B2	1/2013	Gruchala et al.	8,505,073 B2	8/2013	Taglienti et al.
8,364,089 B2	1/2013	Phillips	8,509,082 B2	8/2013	Heinz et al.
8,364,806 B2	1/2013	Short et al.	8,514,927 B2	8/2013	Sundararajan et al.
8,369,274 B2	2/2013	Sawai	8,516,552 B2	8/2013	Raleigh
8,370,477 B2	2/2013	Short et al.	8,520,589 B2	8/2013	Bhatt et al.
8,370,483 B2	2/2013	Choong et al.	8,520,595 B2	8/2013	Yadav et al.
8,374,090 B2	2/2013	Morrill et al.	8,521,110 B2	8/2013	Rofougaran
8,374,592 B2	2/2013	Proctor, Jr. et al.	8,521,775 B1	8/2013	Poh et al.
8,375,128 B2	2/2013	Tofighbakhsh et al.	8,522,039 B2	8/2013	Hyndman et al.
8,375,136 B2	2/2013	Roman et al.	8,522,249 B2	8/2013	Beaule
8,379,847 B2	2/2013	Bell et al.	8,522,337 B2	8/2013	Adusumilli et al.
8,380,247 B2	2/2013	Engstrom	8,523,547 B2	9/2013	Pekrul
8,385,199 B1	2/2013	Coward et al.	8,526,329 B2	9/2013	Mahany
8,385,896 B2	2/2013	Proctor, Jr. et al.	8,527,410 B2	9/2013	Markki et al.
8,385,964 B2	2/2013	Haney	8,527,662 B2	9/2013	Biswas et al.
8,385,975 B2	2/2013	Forutanpour	8,528,068 B1	9/2013	Weglein et al.
8,386,386 B1	2/2013	Zhu	8,531,954 B2	9/2013	McNaughton et al.
8,391,262 B2	3/2013	Maki et al.	8,531,995 B2	9/2013	Khan et al.
8,391,834 B2	3/2013	Raleigh	8,532,610 B2	9/2013	Manning Cassett et al.
8,392,982 B2	3/2013	Harris et al.	8,533,775 B2	9/2013	Alcorn et al.
8,396,458 B2	3/2013	Raleigh	8,538,394 B2	9/2013	Zimmerman et al.
8,396,929 B2	3/2013	Helfman et al.	8,538,421 B2	9/2013	Brisebois et al.
8,401,968 B1	3/2013	Schattauer et al.	8,538,458 B2	9/2013	Haney
8,402,165 B2	3/2013	Deu-Ngoc et al.	8,539,544 B2	9/2013	Garimella et al.
8,402,540 B2	3/2013	Kapoor et al.	8,539,561 B2	9/2013	Gupta et al.
8,406,427 B2	3/2013	Chand et al.	8,543,265 B2	9/2013	Ekhaguere et al.
8,406,736 B2	3/2013	Das et al.	8,543,814 B2	9/2013	Laitinen et al.
8,407,472 B2	3/2013	Hao et al.	8,544,105 B2	9/2013	McLean et al.
8,407,763 B2	3/2013	Weller et al.	8,548,427 B2	10/2013	Chow et al.
8,411,587 B2	4/2013	Curtis et al.	8,548,428 B2	10/2013	Raleigh
8,411,691 B2	4/2013	Aggarwal	8,549,173 B1	10/2013	Wu et al.
8,412,798 B1	4/2013	Wang	8,554,876 B2	10/2013	Winsor
8,413,245 B2	4/2013	Kraemer et al.	8,559,369 B2	10/2013	Barkan
8,418,168 B2	4/2013	Tyhurst et al.	8,565,746 B2	10/2013	Hoffman
8,422,988 B1	4/2013	Keshav	8,566,236 B2	10/2013	Busch
8,423,016 B2	4/2013	Buckley et al.	8,571,474 B2	10/2013	Chavez et al.
8,429,403 B2	4/2013	Moret et al.	8,571,501 B2	10/2013	Miller et al.
8,429,409 B1	4/2013	Wall et al.	8,571,993 B2	10/2013	Kocher et al.
8,437,734 B2	5/2013	Ray et al.	8,572,117 B2	10/2013	Rappaport
8,441,955 B2	5/2013	Wilkinson et al.	8,572,256 B2	10/2013	Babbar
			8,583,499 B2	11/2013	De Judicibus et al.
			8,588,240 B2	11/2013	Ramankutty et al.
			8,589,541 B2	11/2013	Raleigh et al.
			8,589,955 B2	11/2013	Roundtree et al.

(56)

References Cited

U.S. PATENT DOCUMENTS

8,594,665	B2	11/2013	Anschutz	8,971,841	B2	3/2015	Menezes et al.
8,600,895	B2	12/2013	Felsher	8,971,912	B2	3/2015	Chou et al.
8,601,125	B2	12/2013	Huang et al.	8,972,537	B2	3/2015	Bastian et al.
8,605,691	B2	12/2013	Soomro et al.	8,977,284	B2	3/2015	Reed
8,619,735	B2	12/2013	Montemurro et al.	8,995,952	B1	3/2015	Baker et al.
8,620,257	B2	12/2013	Qiu et al.	9,002,342	B2	4/2015	Tenhunen et al.
8,621,056	B2	12/2013	Coussemaeker et al.	9,014,973	B2	4/2015	Ruckart
8,626,115	B2	1/2014	Raleigh et al.	9,015,331	B2	4/2015	Lai et al.
8,630,314	B2	1/2014	York	9,030,934	B2	5/2015	Shah et al.
8,631,428	B2	1/2014	Scott et al.	9,032,427	B2	5/2015	Gallant et al.
8,634,425	B2	1/2014	Gorti et al.	9,049,010	B2	6/2015	Jueneman et al.
8,635,164	B2	1/2014	Rosenhaft et al.	9,064,275	B1	6/2015	Lu et al.
8,639,215	B2	1/2014	McGregor et al.	9,111,088	B2	8/2015	Ghai et al.
8,644,702	B1	2/2014	Kalajan	9,135,037	B1	9/2015	Petrescu-Prahova et al.
8,644,813	B1	2/2014	Gailloux et al.	9,137,286	B1	9/2015	Yuan
8,645,518	B2	2/2014	David	9,172,553	B2	10/2015	Dawes et al.
8,655,357	B1	2/2014	Gazzard et al.	9,173,090	B2	10/2015	Tuchman et al.
8,660,853	B2	2/2014	Robb et al.	9,176,913	B2	11/2015	Millet et al.
8,666,395	B2	3/2014	Silver	9,177,455	B2	11/2015	Remer
8,667,542	B1	3/2014	Bertz et al.	9,282,460	B2	3/2016	Souissi
8,670,334	B2	3/2014	Keohane et al.	9,286,469	B2	3/2016	Kraemer et al.
8,670,752	B2	3/2014	Fan et al.	9,286,604	B2	3/2016	Aabye et al.
8,675,852	B2	3/2014	Maes	9,325,737	B2	4/2016	Gutowski et al.
8,676,682	B2	3/2014	Kalliola	9,326,173	B2	4/2016	Luft
8,676,925	B1	3/2014	Liu et al.	9,344,557	B2	5/2016	Gruchala et al.
8,693,323	B1	4/2014	McDysan	9,367,680	B2	6/2016	Mahaffey et al.
8,694,772	B2	4/2014	Kao et al.	9,402,254	B2	7/2016	Knecht et al.
8,700,729	B2	4/2014	Dua	9,413,546	B2	8/2016	Meier et al.
8,701,015	B2	4/2014	Bonnat	9,589,117	B2	3/2017	Ali et al.
8,705,361	B2	4/2014	Venkataraman et al.	9,609,459	B2	3/2017	Raleigh
8,706,863	B2	4/2014	Fadell	9,634,850	B2	4/2017	Taft et al.
8,713,535	B2	4/2014	Malhotra et al.	2001/0048738	A1	12/2001	Baniak et al.
8,713,641	B1	4/2014	Pagan et al.	2001/0053694	A1	12/2001	Igarashi et al.
8,719,397	B2	5/2014	Levi et al.	2002/0022472	A1	2/2002	Watler et al.
8,719,423	B2	5/2014	Wylde	2002/0049074	A1	4/2002	Eisinger et al.
8,725,899	B2	5/2014	Short et al.	2002/0099848	A1	7/2002	Lee
8,730,842	B2	5/2014	Collins et al.	2002/0116338	A1	8/2002	Gonthier et al.
8,731,519	B2	5/2014	Flynn et al.	2002/0120370	A1	8/2002	Parupudi et al.
8,732,808	B2	5/2014	Sewall et al.	2002/0120540	A1	8/2002	Kende et al.
8,739,035	B2	5/2014	Trethewey	2002/0131404	A1	9/2002	Mehta et al.
8,744,339	B2	6/2014	Halfmann et al.	2002/0138599	A1	9/2002	Dilman et al.
8,761,711	B2	6/2014	Grignani et al.	2002/0138601	A1	9/2002	Piponijs et al.
8,780,857	B2	7/2014	Balasubramanian et al.	2002/0154751	A1	10/2002	Thompson et al.
8,787,249	B2	7/2014	Giaretta et al.	2002/0161601	A1	10/2002	Nauer et al.
8,793,304	B2	7/2014	Lu et al.	2002/0164983	A1	11/2002	Raviv et al.
8,804,517	B2	8/2014	Oerton	2002/0176377	A1	11/2002	Hamilton
8,811,338	B2	8/2014	Jin et al.	2002/0188732	A1	12/2002	Buckman et al.
8,811,991	B2	8/2014	Jain et al.	2002/0191573	A1	12/2002	Whitehill et al.
8,812,525	B1	8/2014	Taylor, III	2002/0199001	A1	12/2002	Wenocur et al.
8,818,394	B2	8/2014	Bienas et al.	2003/0004937	A1	1/2003	Salmenkaita et al.
8,819,253	B2	8/2014	Simeloff et al.	2003/0005112	A1	1/2003	Krautkremer
8,825,109	B2	9/2014	Montemurro et al.	2003/0013434	A1	1/2003	Rosenberg et al.
8,826,411	B2	9/2014	Moen et al.	2003/0018524	A1	1/2003	Fishman et al.
8,831,561	B2	9/2014	Sutaria et al.	2003/0028623	A1	2/2003	Hennessey et al.
8,837,322	B2	9/2014	Venkataramanan et al.	2003/0046396	A1	3/2003	Richter et al.
8,838,686	B2	9/2014	Getchius	2003/0050070	A1	3/2003	Mashinsky et al.
8,838,752	B2	9/2014	Lor et al.	2003/0050837	A1	3/2003	Kim
8,843,849	B2	9/2014	Neil et al.	2003/0084321	A1	5/2003	Tarquini et al.
8,849,297	B2	9/2014	Balasubramanian	2003/0088671	A1	5/2003	Klinker et al.
8,855,620	B2	10/2014	Sievers et al.	2003/0133408	A1	7/2003	Cheng et al.
8,862,751	B2	10/2014	Faccin et al.	2003/0134650	A1	7/2003	Sundar et al.
8,863,111	B2	10/2014	Selitsner et al.	2003/0159030	A1	8/2003	Evans
8,868,725	B2	10/2014	Samba	2003/0161265	A1	8/2003	Cao et al.
8,868,727	B2	10/2014	Yumerefendi et al.	2003/0171112	A1	9/2003	Lupper et al.
8,875,042	B2	10/2014	Lejeune et al.	2003/0182420	A1	9/2003	Jones et al.
8,880,047	B2	11/2014	Konicek et al.	2003/0182435	A1	9/2003	Redlich et al.
8,891,483	B2	11/2014	Connelly et al.	2003/0184793	A1	10/2003	Pineau
8,898,748	B2	11/2014	Burks et al.	2003/0188006	A1	10/2003	Bard
8,908,516	B2	12/2014	Tzamaloukas et al.	2003/0188117	A1	10/2003	Yoshino et al.
8,929,374	B2	1/2015	Tönsing et al.	2003/0220984	A1	11/2003	Jones et al.
8,930,238	B2	1/2015	Coffman et al.	2003/0224781	A1	12/2003	Milford et al.
8,943,551	B2	1/2015	Ganapathy et al.	2003/0229900	A1	12/2003	Reisman
8,948,726	B2	2/2015	Smith et al.	2003/0233332	A1	12/2003	Keeler et al.
8,949,597	B1	2/2015	Reeves et al.	2003/0236745	A1	12/2003	Hartsell et al.
8,966,018	B2	2/2015	Bugwadia et al.	2004/0019539	A1	1/2004	Raman et al.
				2004/0021697	A1	2/2004	Beaton et al.
				2004/0024756	A1	2/2004	Rickard
				2004/0030705	A1	2/2004	Bowman-Amuah
				2004/0039792	A1	2/2004	Nakanishi

(56)

References Cited

U.S. PATENT DOCUMENTS

2004/0044623 A1	3/2004	Wake et al.	2006/0048223 A1	3/2006	Lee et al.
2004/0047358 A1	3/2004	Chen et al.	2006/0068796 A1	3/2006	Millen et al.
2004/0054779 A1	3/2004	Takeshima et al.	2006/0072451 A1	4/2006	Ross
2004/0073672 A1	4/2004	Fascenda	2006/0072550 A1	4/2006	Davis et al.
2004/0082346 A1	4/2004	Skytt et al.	2006/0072646 A1	4/2006	Feher
2004/0098715 A1	5/2004	Aghera et al.	2006/0075506 A1	4/2006	Sanda et al.
2004/0102182 A1	5/2004	Reith et al.	2006/0085543 A1	4/2006	Hrastar et al.
2004/0103193 A1	5/2004	Pandya et al.	2006/0095517 A1	5/2006	O'Connor et al.
2004/0107360 A1	6/2004	Herrmann et al.	2006/0098627 A1	5/2006	Karaoguz et al.
2004/0127200 A1	7/2004	Shaw et al.	2006/0099970 A1	5/2006	Morgan et al.
2004/0127208 A1	7/2004	Nair et al.	2006/0101507 A1	5/2006	Camenisch
2004/0132427 A1	7/2004	Lee et al.	2006/0112016 A1	5/2006	Ishibashi
2004/0133668 A1	7/2004	Nicholas, III	2006/0114821 A1	6/2006	Willey et al.
2004/0137890 A1	7/2004	Kalke	2006/0114832 A1	6/2006	Hamilton et al.
2004/0168052 A1	8/2004	Clisham et al.	2006/0126562 A1	6/2006	Liu
2004/0170191 A1	9/2004	Guo et al.	2006/0135144 A1	6/2006	Jothipragasam
2004/0176104 A1	9/2004	Arcens	2006/0136882 A1	6/2006	Noonan et al.
2004/0198331 A1	10/2004	Coward et al.	2006/0143066 A1	6/2006	Calabria
2004/0203755 A1	10/2004	Brunet et al.	2006/0143098 A1	6/2006	Lazaridis
2004/0203833 A1	10/2004	Rathunde et al.	2006/0156398 A1	7/2006	Ross et al.
2004/0225561 A1	11/2004	Hertzberg et al.	2006/0160536 A1	7/2006	Chou
2004/0225898 A1	11/2004	Frost et al.	2006/0165060 A1	7/2006	Dua
2004/0236547 A1	11/2004	Rappaport et al.	2006/0168128 A1	7/2006	Sistla et al.
2004/0243680 A1	12/2004	Mayer	2006/0173959 A1	8/2006	McKelvie et al.
2004/0243992 A1	12/2004	Gustafson et al.	2006/0174035 A1	8/2006	Tufail
2004/0249918 A1	12/2004	Sunshine	2006/0178917 A1	8/2006	Merriam et al.
2004/0255145 A1	12/2004	Chow	2006/0178918 A1	8/2006	Mikurak
2004/0259534 A1	12/2004	Chaudhari et al.	2006/0182137 A1	8/2006	Zhou et al.
2004/0260766 A1	12/2004	Barros et al.	2006/0183462 A1	8/2006	Kolehmainen
2004/0267872 A1	12/2004	Serdy et al.	2006/0190314 A1	8/2006	Hernandez
2005/0007993 A1	1/2005	Chambers et al.	2006/0190987 A1	8/2006	Ohta et al.
2005/0009499 A1	1/2005	Koster	2006/0199608 A1	9/2006	Dunn et al.
2005/0021995 A1	1/2005	Lal et al.	2006/0200663 A1	9/2006	Thornton
2005/0041617 A1	2/2005	Huotari et al.	2006/0206709 A1	9/2006	Labrou et al.
2005/0048950 A1	3/2005	Morper	2006/0206904 A1	9/2006	Watkins et al.
2005/0055291 A1	3/2005	Bevente et al.	2006/0218395 A1	9/2006	Maes
2005/0055309 A1	3/2005	Williams et al.	2006/0233108 A1	10/2006	Krishnan
2005/0055595 A1	3/2005	Frazer et al.	2006/0233166 A1	10/2006	Bou-Diab et al.
2005/0060266 A1	3/2005	Demello et al.	2006/0236095 A1	10/2006	Smith et al.
2005/0060525 A1	3/2005	Schwartz et al.	2006/0242685 A1	10/2006	Heard et al.
2005/0075115 A1	4/2005	Corneille et al.	2006/0258341 A1	11/2006	Miller et al.
2005/0079863 A1	4/2005	Macaluso	2006/0277590 A1	12/2006	Limont et al.
2005/0091505 A1	4/2005	Riley et al.	2006/0291419 A1	12/2006	McConnell et al.
2005/0096024 A1	5/2005	Bicker et al.	2006/0291477 A1	12/2006	Croak et al.
2005/0097516 A1	5/2005	Donnelly et al.	2007/0005795 A1	1/2007	Gonzalez
2005/0107091 A1	5/2005	Vannithamby et al.	2007/0019670 A1	1/2007	Falardeau
2005/0108075 A1	5/2005	Douglis et al.	2007/0022289 A1	1/2007	Alt et al.
2005/0111463 A1	5/2005	Leung et al.	2007/0025301 A1	2/2007	Petersson et al.
2005/0128967 A1	6/2005	Scobbie	2007/0033194 A1	2/2007	Srinivas et al.
2005/0135264 A1	6/2005	Popoff et al.	2007/0033197 A1	2/2007	Scherzer et al.
2005/0163320 A1	7/2005	Brown et al.	2007/0036312 A1	2/2007	Cai et al.
2005/0166043 A1	7/2005	Zhang et al.	2007/0055694 A1	3/2007	Ruge et al.
2005/0183143 A1	8/2005	Anderholm et al.	2007/0060200 A1	3/2007	Boris et al.
2005/0186948 A1	8/2005	Gallagher et al.	2007/0061243 A1	3/2007	Ramer et al.
2005/0198377 A1	9/2005	Ferguson et al.	2007/0061800 A1	3/2007	Cheng et al.
2005/0216421 A1	9/2005	Barry et al.	2007/0061878 A1	3/2007	Hagiu et al.
2005/0228985 A1	10/2005	Ylikoski et al.	2007/0073899 A1	3/2007	Judge et al.
2005/0238046 A1	10/2005	Hassan et al.	2007/0076616 A1	4/2007	Ngo et al.
2005/0239447 A1	10/2005	Holzman et al.	2007/0093243 A1	4/2007	Kapadekar et al.
2005/0245241 A1	11/2005	Durand et al.	2007/0100981 A1	5/2007	Adamczyk et al.
2005/0246282 A1	11/2005	Naslund et al.	2007/0101426 A1	5/2007	Lee et al.
2005/0250508 A1	11/2005	Guo et al.	2007/0104126 A1	5/2007	Calhoun et al.
2005/0250536 A1	11/2005	Deng et al.	2007/0109983 A1	5/2007	Shankar et al.
2005/0254435 A1	11/2005	Moakley et al.	2007/0130283 A1	6/2007	Klein et al.
2005/0266825 A1	12/2005	Clayton	2007/0130315 A1	6/2007	Friend et al.
2005/0266880 A1	12/2005	Gupta	2007/0140113 A1	6/2007	Gemelos
2006/0014519 A1	1/2006	Marsh et al.	2007/0140145 A1	6/2007	Kumar et al.
2006/0019632 A1	1/2006	Cunningham et al.	2007/0140275 A1	6/2007	Bowman et al.
2006/0020787 A1	1/2006	Choyi et al.	2007/0143824 A1	6/2007	Shahbazi
2006/0026679 A1	2/2006	Zakas	2007/0147317 A1	6/2007	Smith et al.
2006/0030306 A1	2/2006	Kuhn	2007/0147324 A1	6/2007	McGary
2006/0034256 A1	2/2006	Addagatla et al.	2007/0155365 A1	7/2007	Kim et al.
2006/0035631 A1	2/2006	White et al.	2007/0165630 A1	7/2007	Rasanen
2006/0040642 A1	2/2006	Boris et al.	2007/0168499 A1	7/2007	Chu
2006/0045245 A1	3/2006	Aaron et al.	2007/0171856 A1	7/2007	Bruce et al.
			2007/0174490 A1	7/2007	Choi et al.
			2007/0192460 A1	8/2007	Choi et al.
			2007/0198656 A1	8/2007	Mazzaferri et al.
			2007/0201502 A1	8/2007	Abramson

(56)

References Cited

U.S. PATENT DOCUMENTS

2007/0213054 A1	9/2007	Han	2008/0147454 A1	6/2008	Walker et al.
2007/0220251 A1	9/2007	Rosenberg et al.	2008/0160958 A1	7/2008	Abichandani et al.
2007/0226225 A1	9/2007	Yiu et al.	2008/0162637 A1	7/2008	Adamczyk et al.
2007/0226775 A1	9/2007	Andreasen et al.	2008/0162704 A1	7/2008	Poppett et al.
2007/0234402 A1	10/2007	Khosravi et al.	2008/0164304 A1	7/2008	Narasimhan et al.
2007/0243862 A1	10/2007	Coskun et al.	2008/0166993 A1	7/2008	Gautier et al.
2007/0248100 A1	10/2007	Zuberi et al.	2008/0167027 A1	7/2008	Gautier et al.
2007/0254675 A1	11/2007	Zorlu Ozer et al.	2008/0167033 A1	7/2008	Beckers
2007/0255769 A1	11/2007	Agrawal et al.	2008/0168275 A1	7/2008	DeAtley et al.
2007/0255797 A1	11/2007	Dunn et al.	2008/0168523 A1	7/2008	Ansari et al.
2007/0255848 A1	11/2007	Sewall et al.	2008/0177998 A1	7/2008	Apsangi et al.
2007/0257767 A1	11/2007	Beeson	2008/0178300 A1	7/2008	Brown et al.
2007/0259656 A1	11/2007	Jeong	2008/0183812 A1	7/2008	Paul et al.
2007/0259673 A1	11/2007	Willars et al.	2008/0184127 A1	7/2008	Rafey et al.
2007/0263558 A1	11/2007	Salomone	2008/0189760 A1	8/2008	Rosenberg et al.
2007/0266422 A1	11/2007	Germano et al.	2008/0201266 A1	8/2008	Chua et al.
2007/0274327 A1	11/2007	Kaarela et al.	2008/0207167 A1	8/2008	Bugenhagen
2007/0280453 A1	12/2007	Kelley	2008/0212470 A1	9/2008	Castaneda et al.
2007/0282896 A1	12/2007	Wydroug et al.	2008/0212751 A1	9/2008	Chung
2007/0293191 A1	12/2007	Mir et al.	2008/0219268 A1	9/2008	Dennison
2007/0294395 A1	12/2007	Strub et al.	2008/0221951 A1	9/2008	Stanforth et al.
2007/0294410 A1	12/2007	Pandya et al.	2008/0222692 A1	9/2008	Andersson et al.
2007/0297378 A1	12/2007	Poyhonen et al.	2008/0225748 A1	9/2008	Khemani et al.
2007/0298764 A1	12/2007	Clayton	2008/0229385 A1	9/2008	Feder et al.
2007/0299965 A1	12/2007	Nieh et al.	2008/0229388 A1	9/2008	Maes
2007/0300252 A1	12/2007	Acharya et al.	2008/0235511 A1	9/2008	O'Brien et al.
2008/0005285 A1	1/2008	Robinson et al.	2008/0240373 A1	10/2008	Wilhelm
2008/0005561 A1	1/2008	Brown et al.	2008/0250053 A1	10/2008	Aaltonen et al.
2008/0010379 A1	1/2008	Zhao	2008/0256593 A1	10/2008	Vinberg et al.
2008/0010452 A1	1/2008	Holtzman et al.	2008/0259924 A1	10/2008	Gooch et al.
2008/0018494 A1	1/2008	Waite et al.	2008/0262798 A1	10/2008	Kim et al.
2008/0022354 A1	1/2008	Grewal et al.	2008/0263348 A1	10/2008	Zaltsman et al.
2008/0025230 A1	1/2008	Patel et al.	2008/0268813 A1	10/2008	Maes
2008/0032715 A1	2/2008	Jia et al.	2008/0270212 A1	10/2008	Blight et al.
2008/0034063 A1	2/2008	Yee	2008/0279216 A1	11/2008	Sharif-Ahmadi et al.
2008/0034419 A1	2/2008	Mullick et al.	2008/0282319 A1	11/2008	Fontijn et al.
2008/0039102 A1	2/2008	Sewall et al.	2008/0293395 A1	11/2008	Matthews et al.
2008/0049630 A1	2/2008	Kozisek et al.	2008/0298230 A1	12/2008	Luft et al.
2008/0050715 A1	2/2008	Golczewski et al.	2008/0305793 A1	12/2008	Gallagher et al.
2008/0051076 A1	2/2008	O'Shaughnessy et al.	2008/0311885 A1	12/2008	Dawson et al.
2008/0052387 A1	2/2008	Heinz et al.	2008/0313315 A1	12/2008	Karaoguz et al.
2008/0056273 A1	3/2008	Pelletier et al.	2008/0313730 A1	12/2008	Iftimie et al.
2008/0059474 A1	3/2008	Lim	2008/0316923 A1	12/2008	Fedders et al.
2008/0059743 A1	3/2008	Bychkov et al.	2008/0318547 A1	12/2008	Ballou et al.
2008/0060066 A1	3/2008	Wynn et al.	2008/0318550 A1	12/2008	DeAtley
2008/0062900 A1	3/2008	Rao	2008/0319879 A1	12/2008	Carroll et al.
2008/0064367 A1	3/2008	Nath et al.	2008/0320497 A1	12/2008	Tarkoma et al.
2008/0066149 A1	3/2008	Lim	2009/0005000 A1	1/2009	Baker et al.
2008/0066150 A1	3/2008	Lim	2009/0005005 A1	1/2009	Forstall et al.
2008/0066181 A1	3/2008	Haveson et al.	2009/0006116 A1	1/2009	Baker et al.
2008/0070550 A1	3/2008	Hose	2009/0006200 A1	1/2009	Baker et al.
2008/0077705 A1	3/2008	Li et al.	2009/0006229 A1	1/2009	Sweeney et al.
2008/0080457 A1	4/2008	Cole	2009/0013157 A1	1/2009	Beaule
2008/0081606 A1	4/2008	Cole	2009/0016310 A1	1/2009	Rasal
2008/0082643 A1	4/2008	Storrie et al.	2009/0036111 A1	2/2009	Danford et al.
2008/0083013 A1	4/2008	Soliman et al.	2009/0042536 A1	2/2009	Bernard et al.
2008/0085707 A1	4/2008	Fadell	2009/0044185 A1	2/2009	Krivopaltsev
2008/0089295 A1	4/2008	Keeler et al.	2009/0046707 A1	2/2009	Smires et al.
2008/0089303 A1	4/2008	Wirtanen et al.	2009/0046723 A1	2/2009	Rahman et al.
2008/0095339 A1	4/2008	Elliott et al.	2009/0047989 A1	2/2009	Harmon et al.
2008/0096559 A1	4/2008	Phillips et al.	2009/0048913 A1	2/2009	Shenfield et al.
2008/0098062 A1	4/2008	Balia	2009/0049156 A1	2/2009	Aronsson et al.
2008/0109679 A1	5/2008	Wright et al.	2009/0049518 A1	2/2009	Roman et al.
2008/0120129 A1	5/2008	Seubert et al.	2009/0054030 A1	2/2009	Golds
2008/0120668 A1	5/2008	Yau	2009/0065571 A1	3/2009	Jain
2008/0120688 A1	5/2008	Qiu et al.	2009/0067372 A1	3/2009	Shah et al.
2008/0125079 A1	5/2008	O'Neil et al.	2009/0068984 A1	3/2009	Burnett
2008/0126287 A1	5/2008	Cox et al.	2009/0070379 A1	3/2009	Rappaport
2008/0127304 A1	5/2008	Ginter et al.	2009/0077622 A1	3/2009	Baum et al.
2008/0130534 A1	6/2008	Tomioka	2009/0079699 A1	3/2009	Sun
2008/0130656 A1	6/2008	Kim et al.	2009/0113514 A1	4/2009	Hu
2008/0132201 A1	6/2008	Karlberg	2009/0125619 A1	5/2009	Antani
2008/0132268 A1	6/2008	Choi-Grogan et al.	2009/0132860 A1	5/2009	Liu et al.
2008/0134330 A1	6/2008	Kapoor et al.	2009/0149154 A1	6/2009	Bhasin et al.
2008/0139210 A1	6/2008	Gisby et al.	2009/0157792 A1	6/2009	Fiatal
			2009/0163173 A1	6/2009	Williams
			2009/0172077 A1	7/2009	Roxburgh et al.
			2009/0180391 A1	7/2009	Petersen et al.
			2009/0181662 A1	7/2009	Fleischman et al.

(56)

References Cited

U.S. PATENT DOCUMENTS

2009/0197585 A1 8/2009 Aaron
 2009/0197612 A1 8/2009 Kiiskinen
 2009/0203352 A1 8/2009 Fordon et al.
 2009/0217364 A1 8/2009 Salmela et al.
 2009/0219170 A1 9/2009 Clark et al.
 2009/0248883 A1 10/2009 Suryanarayana et al.
 2009/0254857 A1 10/2009 Romine et al.
 2009/0257379 A1 10/2009 Robinson et al.
 2009/0271514 A1 10/2009 Thomas et al.
 2009/0282127 A1 11/2009 LeBlanc et al.
 2009/0286507 A1 11/2009 O'Neil et al.
 2009/0287921 A1 11/2009 Zhu et al.
 2009/0288140 A1 11/2009 Huber et al.
 2009/0291665 A1 11/2009 Gaskarth et al.
 2009/0299857 A1 12/2009 Brubaker
 2009/0307696 A1 12/2009 Vals et al.
 2009/0307746 A1 12/2009 Di et al.
 2009/0315735 A1 12/2009 Bhavani et al.
 2009/0320110 A1 12/2009 Nicolson et al.
 2010/0017506 A1 1/2010 Fadell
 2010/0020822 A1 1/2010 Zerillo et al.
 2010/0027469 A1 2/2010 Gurajala et al.
 2010/0027559 A1 2/2010 Lin et al.
 2010/0030890 A1 2/2010 Dutta et al.
 2010/0041364 A1 2/2010 Lott et al.
 2010/0041365 A1 2/2010 Lott et al.
 2010/0042675 A1 2/2010 Fujii
 2010/0043068 A1 2/2010 Varadhan et al.
 2010/0071053 A1 3/2010 Ansari et al.
 2010/0075666 A1 3/2010 Garner
 2010/0080202 A1 4/2010 Hanson
 2010/0082431 A1 4/2010 Ramer et al.
 2010/0103820 A1 4/2010 Fuller et al.
 2010/0121744 A1 5/2010 Belz et al.
 2010/0131584 A1 5/2010 Johnson
 2010/0144310 A1 6/2010 Bedingfield
 2010/0151866 A1 6/2010 Karpov et al.
 2010/0153781 A1 6/2010 Hanna
 2010/0167696 A1 7/2010 Smith et al.
 2010/0188975 A1 7/2010 Raleigh
 2010/0188990 A1 7/2010 Raleigh
 2010/0188992 A1 7/2010 Raleigh
 2010/0188994 A1 7/2010 Raleigh
 2010/0190469 A1 7/2010 Vanderveen et al.
 2010/0191576 A1 7/2010 Raleigh
 2010/0191612 A1 7/2010 Raleigh
 2010/0191846 A1 7/2010 Raleigh
 2010/0192170 A1 7/2010 Raleigh
 2010/0192212 A1 7/2010 Raleigh
 2010/0195503 A1 8/2010 Raleigh
 2010/0197268 A1 8/2010 Raleigh
 2010/0198698 A1 8/2010 Raleigh et al.
 2010/0198939 A1 8/2010 Raleigh
 2010/0235329 A1 9/2010 Koren et al.
 2010/0241544 A1 9/2010 Benson et al.
 2010/0248719 A1 9/2010 Scholaert
 2010/0284327 A1 11/2010 Miklos
 2010/0284388 A1 11/2010 Fantini et al.
 2010/0287599 A1 11/2010 He
 2010/0311402 A1 12/2010 Srinivasan et al.
 2010/0318652 A1 12/2010 Samba
 2010/0325420 A1 12/2010 Kanekar
 2011/0004917 A1 1/2011 Saisa et al.
 2011/0013569 A1 1/2011 Scherzer et al.
 2011/0019574 A1 1/2011 Malomsoky et al.
 2011/0081881 A1 4/2011 Baker et al.
 2011/0082790 A1 4/2011 Baker et al.
 2011/0110309 A1 5/2011 Bennett
 2011/0126141 A1 5/2011 King et al.
 2011/0145920 A1 6/2011 Mahaffey et al.
 2011/0159818 A1 6/2011 Scherzer et al.
 2011/0173678 A1 7/2011 Kaippallimalil et al.
 2011/0177811 A1 7/2011 Heckman et al.
 2011/0195700 A1 8/2011 Kukuchka et al.
 2011/0238545 A1 9/2011 Fanaian et al.

2011/0241624 A1 10/2011 Park et al.
 2011/0252430 A1 10/2011 Chapman et al.
 2011/0264923 A1 10/2011 Kocher et al.
 2011/0277019 A1 11/2011 Pritchard, Jr.
 2012/0020296 A1 1/2012 Scherzer et al.
 2012/0029718 A1 2/2012 Davis
 2012/0101952 A1 4/2012 Raleigh et al.
 2012/0108225 A1 5/2012 Luna et al.
 2012/0144025 A1 6/2012 Melander et al.
 2012/0155296 A1 6/2012 Kashanian
 2012/0166364 A1 6/2012 Ahmad et al.
 2012/0166604 A1 6/2012 Fortier et al.
 2012/0196644 A1 8/2012 Scherzer et al.
 2012/0238287 A1 9/2012 Scherzer
 2012/0330792 A1 12/2012 Kashanian
 2013/0024914 A1 1/2013 Ahmed et al.
 2013/0029653 A1 1/2013 Baker et al.
 2013/0030960 A1 1/2013 Kashanian
 2013/0058274 A1 3/2013 Scherzer et al.
 2013/0065555 A1 3/2013 Baker et al.
 2013/0072177 A1 3/2013 Ross et al.
 2013/0084835 A1 4/2013 Scherzer et al.
 2013/0095787 A1 4/2013 Kashanian
 2013/0103376 A1 4/2013 Gaddam et al.
 2013/0111572 A1 5/2013 Gaddam et al.
 2013/0117140 A1 5/2013 Kashanian
 2013/0117382 A1 5/2013 Gaddam et al.
 2013/0144789 A1 6/2013 Aaltonen et al.
 2013/0149994 A1 6/2013 Gaddam et al.
 2013/0183937 A1 7/2013 Neal et al.
 2013/0326356 A9 12/2013 Zheng et al.
 2014/0073291 A1 3/2014 Hildner et al.
 2014/0241342 A1 8/2014 Constantinof

FOREIGN PATENT DOCUMENTS

CN 1345154 A 4/2002
 CN 1508734 A 6/2004
 CN 1538730 A 10/2004
 CN 1567818 A 1/2005
 CN 101035308 A 3/2006
 CN 1801829 A 7/2006
 CN 1802839 A 7/2006
 CN 1889777 A 7/2006
 CN 101155343 A 9/2006
 CN 1867024 A 11/2006
 CN 1878160 A 12/2006
 CN 1878160 A 12/2006
 CN 1937511 A 3/2007
 CN 101123553 A 9/2007
 CN 101080055 A 11/2007
 CN 101115248 A 1/2008
 CN 101127988 A 2/2008
 CN 101183958 A 5/2008
 CN 101335666 A 12/2008
 CN 101341764 A 1/2009
 CN 101815275 A 8/2010
 EP 1098490 A2 5/2001
 EP 1289326 3/2003
 EP 1463238 9/2004
 EP 1503548 A1 2/2005
 EP 1545114 6/2005
 EP 1545114 A1 6/2005
 EP 1739518 1/2007
 EP 1772988 4/2007
 EP 1850575 10/2007
 EP 1887732 2/2008
 EP 1887732 A1 2/2008
 EP 1942698 A1 7/2008
 EP 1978772 10/2008
 EP 2007065 12/2008
 EP 2007065 A1 12/2008
 EP 2026514 A1 2/2009
 EP 2466831 A1 6/2012
 JP 3148713 B2 3/2001
 JP 2005339247 A 12/2005
 JP 2006-041989 2/2006
 JP 2006155263 A 6/2006
 JP 2006-197137 7/2006

(56)

References Cited

FOREIGN PATENT DOCUMENTS

JP	2006-344007	12/2006
JP	2007-318354	12/2007
JP	2008-301121	12/2008
JP	2009-111919	5/2009
JP	2009-212707	9/2009
JP	2009-218773	9/2009
JP	2009-232107	10/2009
WO	1998058505	12/1998
WO	1999027723 A1	6/1999
WO	1999065185	12/1999
WO	0208863	1/2002
WO	2002045315	6/2002
WO	2002067616	8/2002
WO	2002067616 A1	8/2002
WO	2002093877	11/2002
WO	2003014891	2/2003
WO	2003017063	2/2003
WO	2003017063 A2	2/2003
WO	2003017065	2/2003
WO	2003017065 A2	2/2003
WO	2003058880	7/2003
WO	2004028070	4/2004
WO	2004064306 A2	7/2004
WO	2004077797	9/2004
WO	2004095753	11/2004
WO	2005008995	1/2005
WO	2005053335 A1	6/2005
WO	2005083934	9/2005
WO	2006004467	1/2006
WO	2006004784	1/2006
WO	2006012610	2/2006
WO	2006050758	5/2006
WO	2006073837	7/2006
WO	2006077481	7/2006
WO	2006093961	9/2006
WO	2006120558	11/2006
WO	2006130960	12/2006
WO	2007001833	1/2007
WO	2007014630	2/2007
WO	2007018363	2/2007
WO	2007053848	5/2007
WO	2007068288 A1	6/2007
WO	2007069245	6/2007
WO	2007097786	8/2007
WO	2007107701	9/2007
WO	2007120310	10/2007
WO	2007124279	11/2007
WO	2007126352	11/2007
WO	2007129180 A2	11/2007
WO	2007133844	11/2007
WO	2008017837	2/2008
WO	2008051379	5/2008
WO	2008066419	6/2008
WO	2008080139	7/2008
WO	2008080430	7/2008
WO	2008099802	8/2008
WO	2009008817	1/2009
WO	2009091295	7/2009
WO	2010088413	8/2010
WO	2010128391 A2	11/2010
WO	2011002450	1/2011
WO	2011002450 A1	1/2011
WO	2011149532 A1	12/2011
WO	2012047275	4/2012

OTHER PUBLICATIONS

“End to End QoS Solution for Real-time Multimedia Application,” Computer Engineering and Applications, 2007, 43 (4): 155-159, by Tan Zu-guo, Wang Wen-juan; Information and Science School, Zhanjian Normal College, Zhan jiang, Guangdong 524048, China.
 “ASA/PIX: Allow Split Tunneling for VPN Clients on the ASA Configuration Example,” Document ID 70917, Jan. 10, 2008.

VerizonWireless.com news, “Verizon Wireless Adds to Portfolio of Cosumer-Friendly Tools With Introduction of Usage Controls, Usage Controls and Chaperone 2.0 Offer Parents Full Family Security Solution,” Aug. 18, 2008.

“The Construction of Intelligent Residential District in Use of Cable Television Network,” Shandong Science, vol. 13, No. 2, Jun. 2000.

“Communication Concepts for Mobile Agent Systems,” by Joachim Baumann et al.; Inst. Of Parallel and Distributed High-Performance Systems, Univ. of Stuttgart, Germany, pp. 123-135, 1997.

“Prevent iCloud Documents & Data from using your data plan,” Oct. 26, 2011; CNET webarchive, by Jason Ciprian.

Dixon et al., Triple Play Digital Services: Comcast and Verizon (Digital Phone, Television, and Internet), Aug. 2007.

3rd Generation Partnership Project; “Technical Specification Group Services and System Aspects; IP Flow Mobility and seamless WLAN offload; Stage 2,” Release 10, Document No. 3GPP TS 23.261, V1.0.0, Mar. 2010.

3rd Generation Partnership Project, “Technical Specification Group Core Network and Terminals; Access Network Discovery and Selection Function (ANDSF) Management Object (MO),” Release 9, Document No. 3GPP TS 24.312, V9.1.0, Mar. 2010.

Ahmed et al., “Multi Access Data Network Connectivity and IP Flow Mobility in Evolved Packet System (EPS),” 2010 IEEE.

Li, Yu, “Dedicated E-Reading Device: The State of the Art and the Challenges,” Scroll, vol. 1, No. 1, 2008.

Nilsson et al., “A Novel MAC Scheme for Solving the QoS Parameter Adjustment Problem in IEEE802.11e EDCA,” Feb. 2006.

Oppliger, Rolf, “Internet Security: Firewalls and Bey,” Communications of the ACM, May 1997, vol. 40. No. 5.

Rao et al., “Evolution of Mobile Location-Based Services,” Communication of the ACM, Dec. 2003.

Steglich, Stephan, “I-Centric User Interaction,” Nov. 21, 2003.

Van Eijk, et al., “GigaMobile, Agent Technology for Designing Personalized Mobile Service Brokerage,” Jul. 1, 2002.

Zhu et al., “A Survey of Quality of Service in IEEE 802.11 Networks,” IEEE Wireless Communications, Aug. 2004.

Anton, B. et al., “Best Current Practices for Wireless Internet Service Provider (WISP) Roaming”, Release Date Feb. 2003, Version 1.0; Wi-Fi Alliance—Wireless ISP Roaming (WISPr).

Ruckus Wireless—White Paper; “Smarter Wi-Fi for Mobile Operator Infrastructures” 2010.

Accuris Networks, “The Business Value of Mobile Data Offload—a White Paper”, 2010.

Wireless Broadband Alliance, “WISPr 2.0, Apr. 8, 2010”; Version 01.00.

Thurston, Richard, “WISPr 2.0 Boosts Roaming Between 3G and Wi-Fi”; Jun. 23, 2010; Web page from zdnet.com; Zdnet.com/wispr-2-0-boosts-roaming-between-3g-and-wi-fi-3040089325/.

Wi-Fi Alliance Technical Committee Hotspot 2.0 Technical Task Group, “Hotspot 2.0 (Release 1) Technical Specification—Version 1.0.0”; 2012.

Wi-Fi Alliance Hotspot 2.0 Technical Task Group, “Wi-Fi Certified Passpoint™ (Release 1) Deployment Guidelines—Version 1.0—Oct. 2012”.

3rd Generation Partnership Project, “Technical Specification Group Services and System Aspects; General Packet Radio Service (GPRS) Enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) Access,” Release 8, Document No. 3GPP TS 23.401, V8.4.0, Dec. 2008.

3rd Generation Partnership Project, “Technical Specification Group Services and System Aspects; Policy and Charging Control Architecture,” Release 8, Document No. 3GPP TS 23.203, V8.4.0, Dec. 2008.

Alonistioti et al., “Intelligent Architectures Enabling Flexible Service Provision and Adaptability,” 2002.

Amazon Technologies, Inc., “Kindle™ User’s Guide,” 3rd Edition, Copyright 2004-2009.

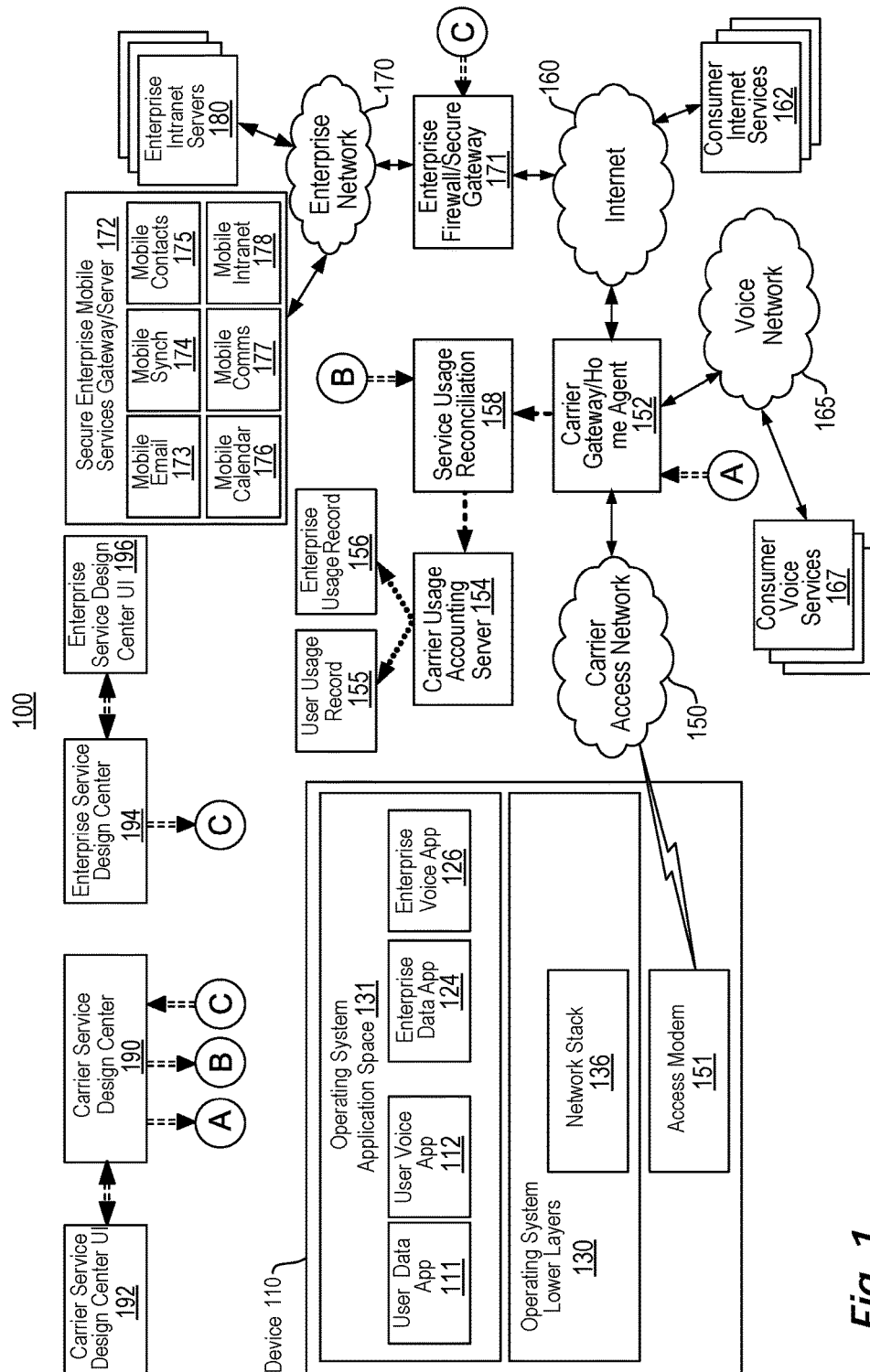
Chandrasekhar et al., “Femtocell Networks: A Survey,” Jun. 28, 2008.

Chaouchi et al., “Policy Based Networking in the Integration Effort of 4G Networks and Services,” 2004 IEEE.

(56)

References Cited**OTHER PUBLICATIONS**

- Cisco Systems, Inc., "Cisco Mobile Exchange (CMX) Solution Guide: Chapter 2—Overview of GSM, GPRS, and UMTS," Nov. 4, 2008.
- Dikaiakos et al., "A Distributed Middleware Infrastructure for Personalized Services," Nov. 24, 2003.
- European Commission, "Data Roaming Tariffs—Transparency Measures," [online] retrieved from http://web.archive.org/web/20081220232754/http://ec.europa.eu/information_society/activities/roaming/data/measures/index_en.htm, Dec. 20, 2008 [retrieved May 16, 2012].
- Farooq et al., "An IEEE 802.16 WiMax Module for the NS-3 Simulator," Mar. 2-6, 2009.
- Han et al., "Information Collection Services for Qos-Aware Mobile Applications," 2005.
- Hartmann et al., "Agent-Based Banking Transactions & Information Retrieval—What About Performance Issues?" 1999.
- Hewlett-Packard Development Company, LP, "IP Multimedia Services Charging," white paper, Jan. 2006.
- Hossain et al., "Gain-Based Selection of Ambient Media Services in Pervasive Environments," *Mobile Networks and Applications*, Oct. 3, 2008.
- Knight et al., "Layer 2 and 3 Virtual Private Networks: Taxonomy, Technology, and Standardization Efforts," *IEEE Communications Magazine*, Jun. 2004.
- Koutsopoulou et al., "Middleware Platform for the Support of Charging Reconfiguration Actions," 2005.
- Kyriakakos et al., "Ubiquitous Service Provision in Next Generation Mobile Networks," *Proceedings of the 13th IST Mobile and Wireless Communications Summit*, Lyon, France, Jun. 2004.
- Ahmed et al., "A Context-Aware Vertical Handover Decision Algorithm for Multimode Mobile Terminals and Its Performance," *BenQ Mobile*, Munich Germany; University of Klagenfurt, Klagenfurt, Austria; 2006.
- Kassar et al., "An overview of vertical handover decision strategies in heterogeneous wireless networks," *ScienceDirect*, University Pierre & Marie Curie, Paris, France, Jun. 5, 2007.
- Schiller et al., "Location-Based Services," *The Morgan Kaufmann Series in Data Management Systems*, 2004.
- Sadeh et al., "Understanding and Capturing People's Privacy Policies in a Mobile Social Networking Application," *ISR School of Computer Science*, Carnegie Mellon University, 2007.
- Jing et al., "Client-Server Computing in Mobile Environments," *GTE Labs. Inc., Purdue University, ACM Computing Surveys*, vol. 31, No. 2, Jun. 1999.
- Rivadeneyra et al., "A communication architecture to access data services through GSM," *San Sebastian*, Spain, 1998.
- Loopt User Guide, *metroPCS*, Jul. 17, 2008.
- "Jentro Technologies launches Zenlet platform to accelerate location-based content delivery to mobile devices," *The Mobile Internet*, Boston, MA, Feb. 2008.
- NetLimiter Lite 4.0.19.0; <http://www.heise.de/download/netlimiter-lite-3617703.html> from vol. 14/2007.
- Muntermann et al., "Potentiale und Sicherheitsanforderungen mobiler Finanzinformationsdienste und deren Systeminfrastrukturen," *Chair of Mobile Commerce & Multilateral Security*, Goethe Univ. Frankfurt, 2004.
- Kasper et al., "Subscriber Authentication in mobile cellular Networks with virtual software SIM Credentials using Trusted Computing," *Fraunhofer-Institute for Secure Information Technology SIT*, Darmstadt, Germany; *ICACT 2008*.
- Fujitsu, "Server Push Technology Survey and Bidirectional Communication in HTTP Browser," Jan. 9, 2008 (JP).
- Roy et al., "Energy Management in Mobile Devices with the Cinder Operating System", *Stanford University, MIT CSAIL*, Jun. 3, 2010.
- Windows7 Power Management, published Apr. 2009.
- Quintana, David, "Mobile Multitasking," Apr. 14, 2010.
- Open Mobile Alliance (OMA), *Push Architecture, Candidate Version 2.2*; Oct. 2, 2007; OMA-AD-Push-V2_2-20071002-C.
- "Ads and movies on the run," *the Gold Coast Bulletin*, Southport, Qld, Jan. 29, 2008.
- Richtel, "Cellphone consumerism; If even a debit card is too slow, now you have a new way to act on impulse: [National Edition]," *National Post*, Canada, Oct. 2, 2007.
- Kim, "Free wireless a high-wire act; MetroFi needs to draw enough ads to make service add profits," *San Francisco Chronicle*, Aug. 21, 2006.
- Koutsopoulou et al., "Charging, Accounting and Billing Management Schemes in Mobile Telecommunication Networks and the Internet," *IEEE Communications Surveys & Tutorials*, First Quarter 2004, vol. 6, No. 1.
- Sun et al., "Towards Connectivity Management Adaptability: Context Awareness in Policy Representation and End-to-end Evaluation Algorithm," *Dept. of Electrical and Information Engineering, Univ. of Oulu*, Finland, 2004.
- Sabat, "The evolving mobile wireless value chain and market structure," Nov. 2002.
- Nuzman et al., "A compound model for TCP connection arrivals for LAN and WAN applications," Oct. 22, 2002.
- Kuntze et al., "Trustworthy content push," *Fraunhofer-Institute for Secure Information Technology SIT; Germany; WCNC 2007 proceedings, IEEE*.
- Blackberry Mobile Data System, version 4.1, *Technical Overview*, 2006.
- Client Guide for Symantec Endpoint Protection and Symantec Network Access Control, 2007.
- Ehnert, "Small application to monitor IP traffic on a Blackberry—1.01.03", Mar. 27, 2008; <http://www.ehnert.net/MiniMoni/>.
- Android Cupcake excerpts, *The Android Open Source Project*, Feb. 10, 2009.



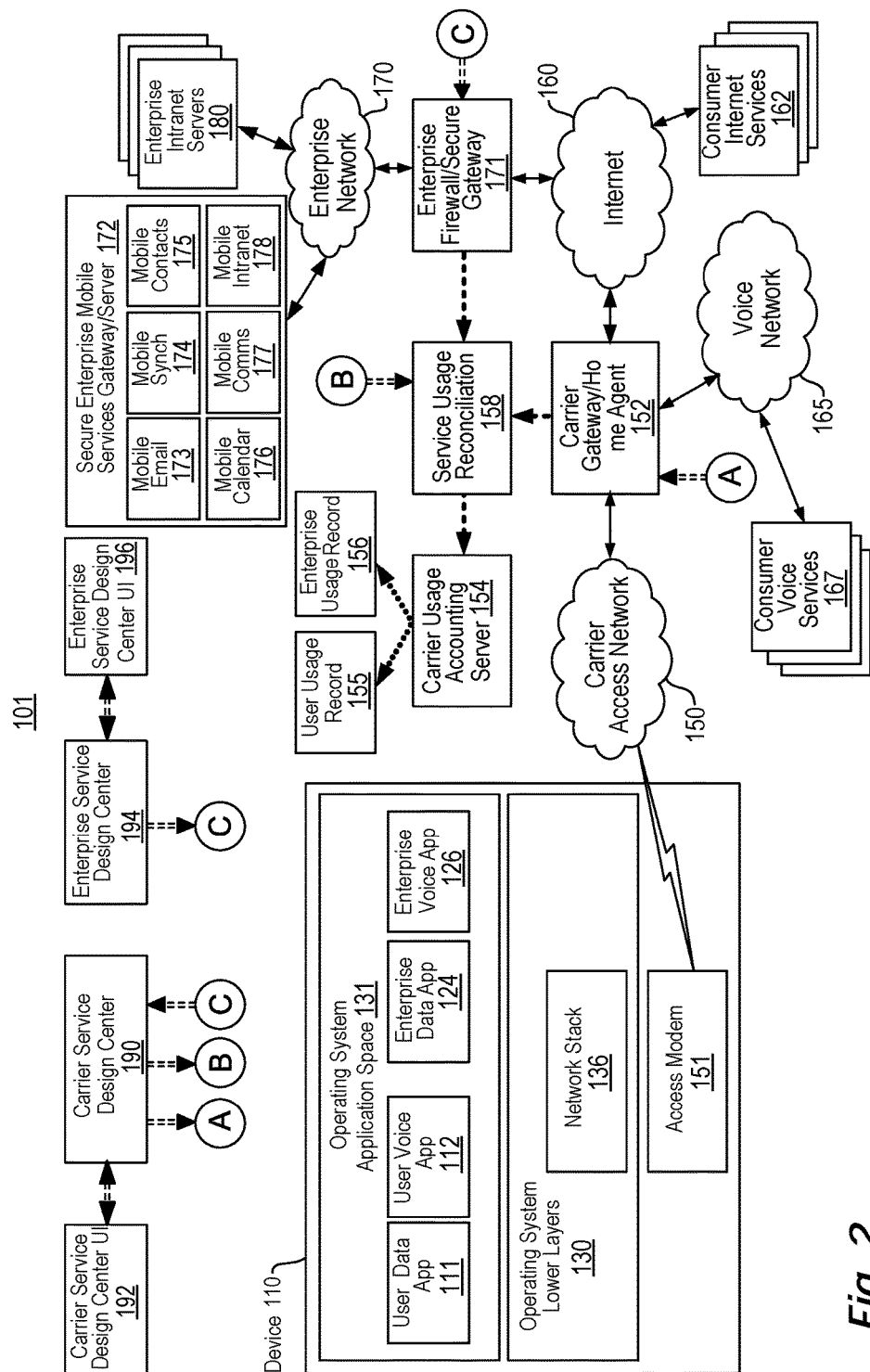


Fig. 2

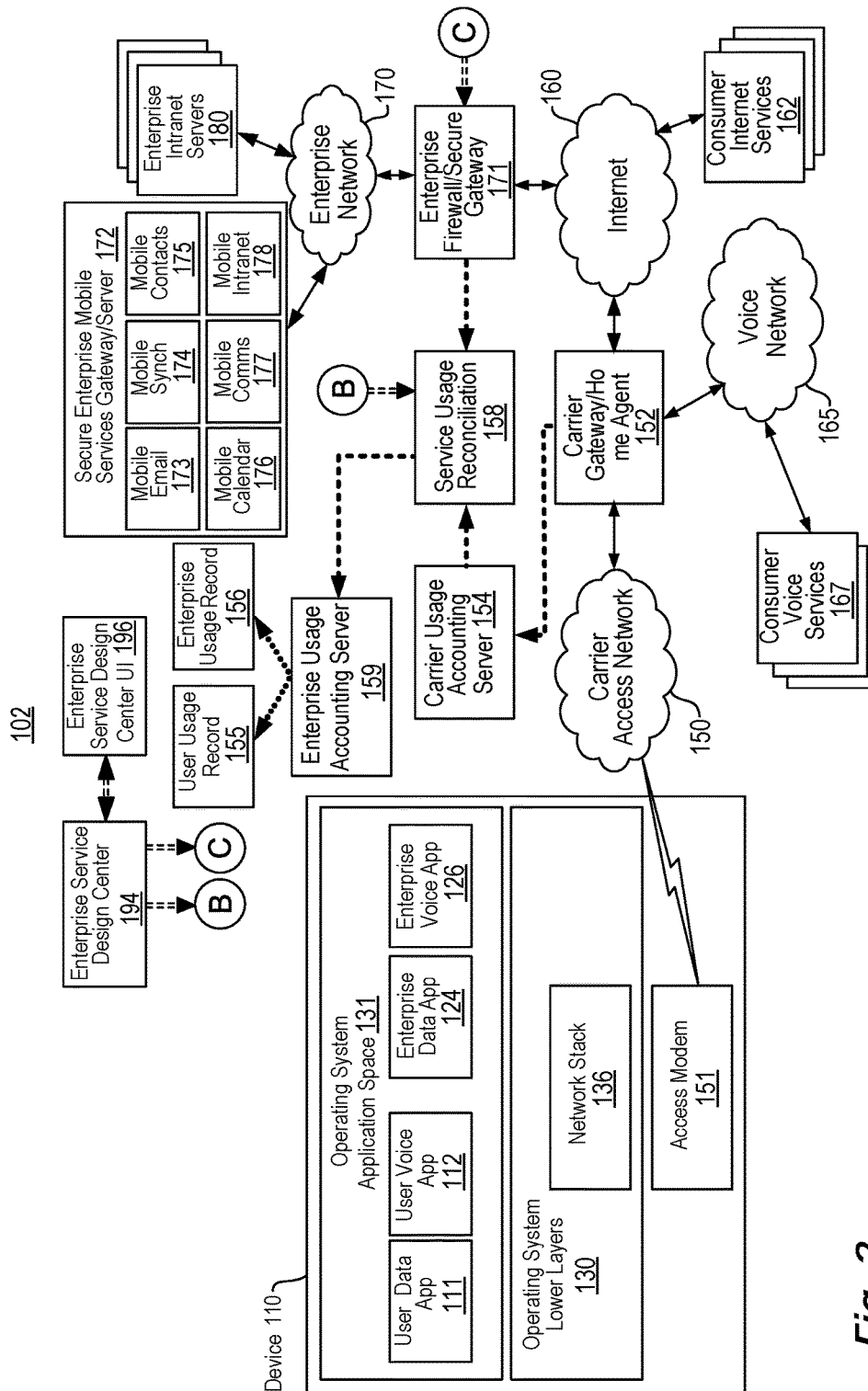


Fig. 3

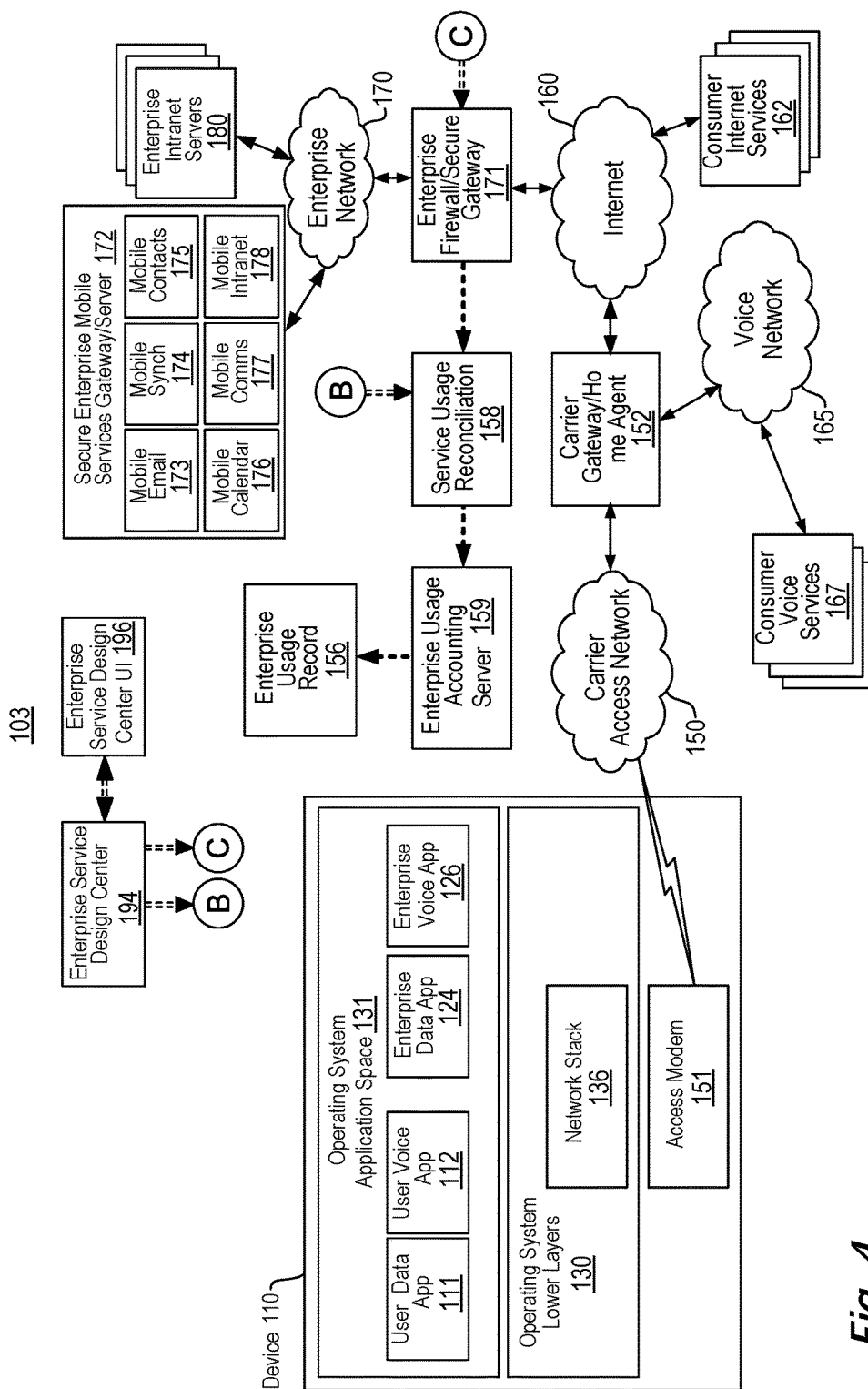
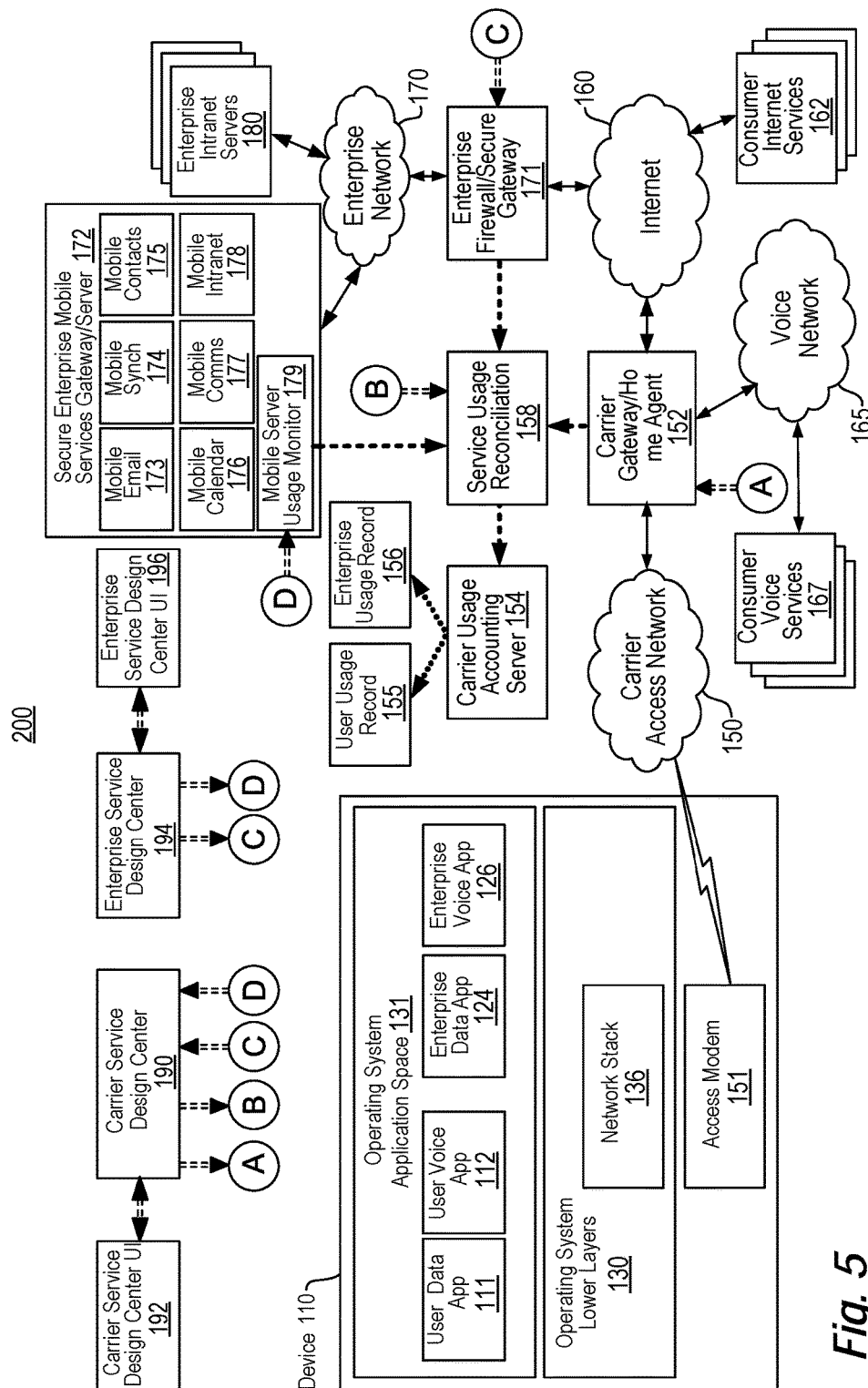
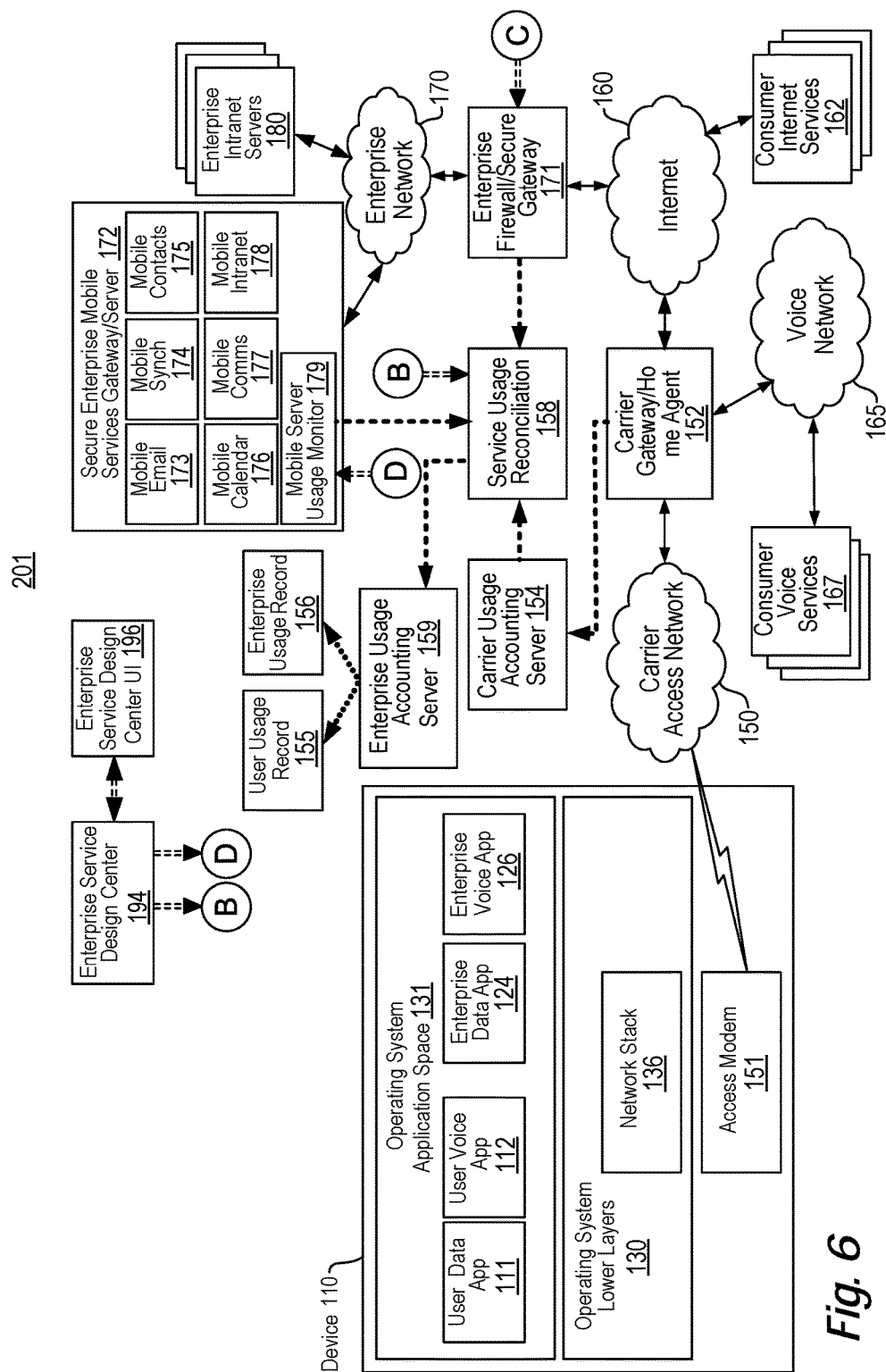


Fig. 4





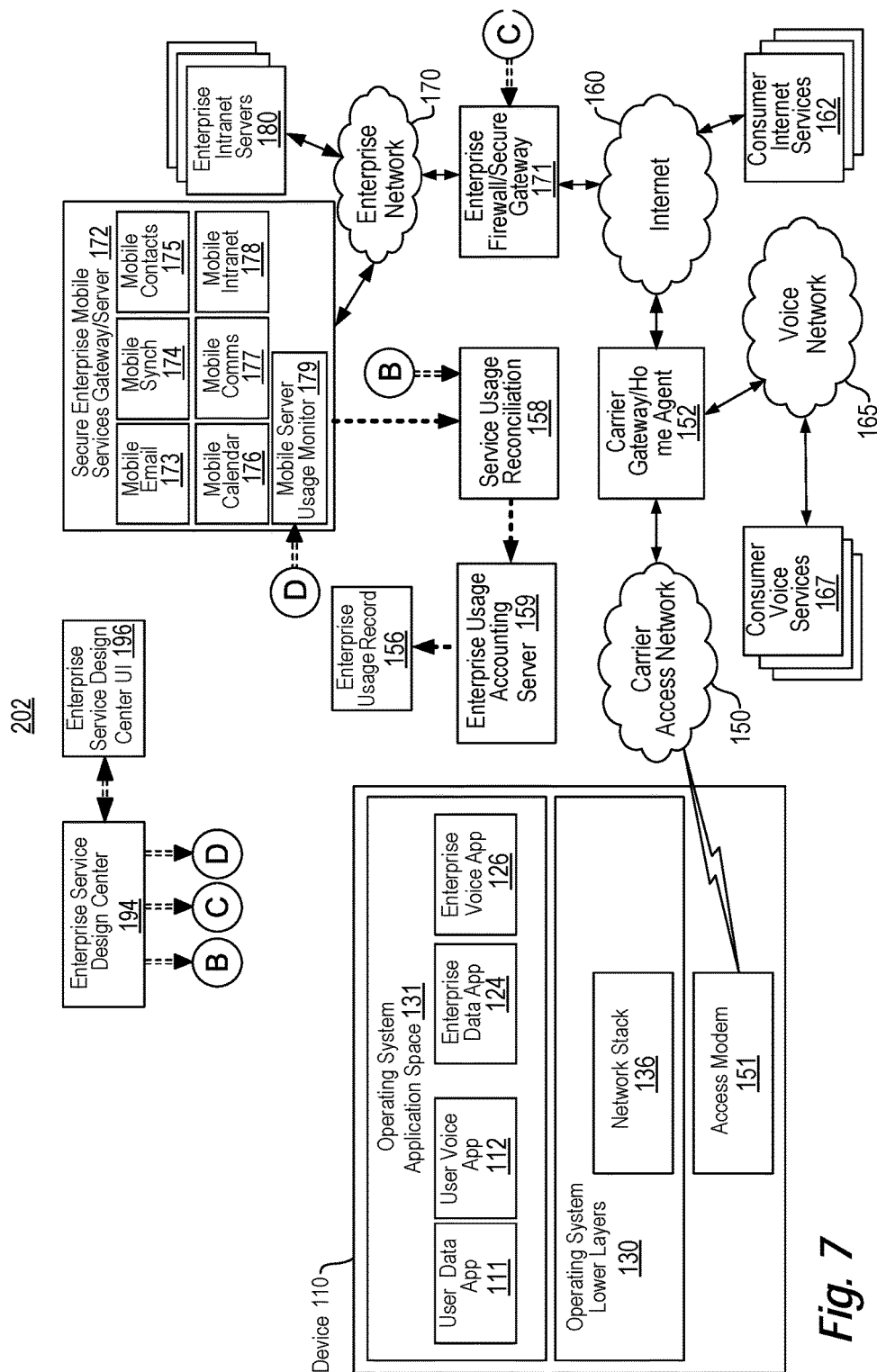
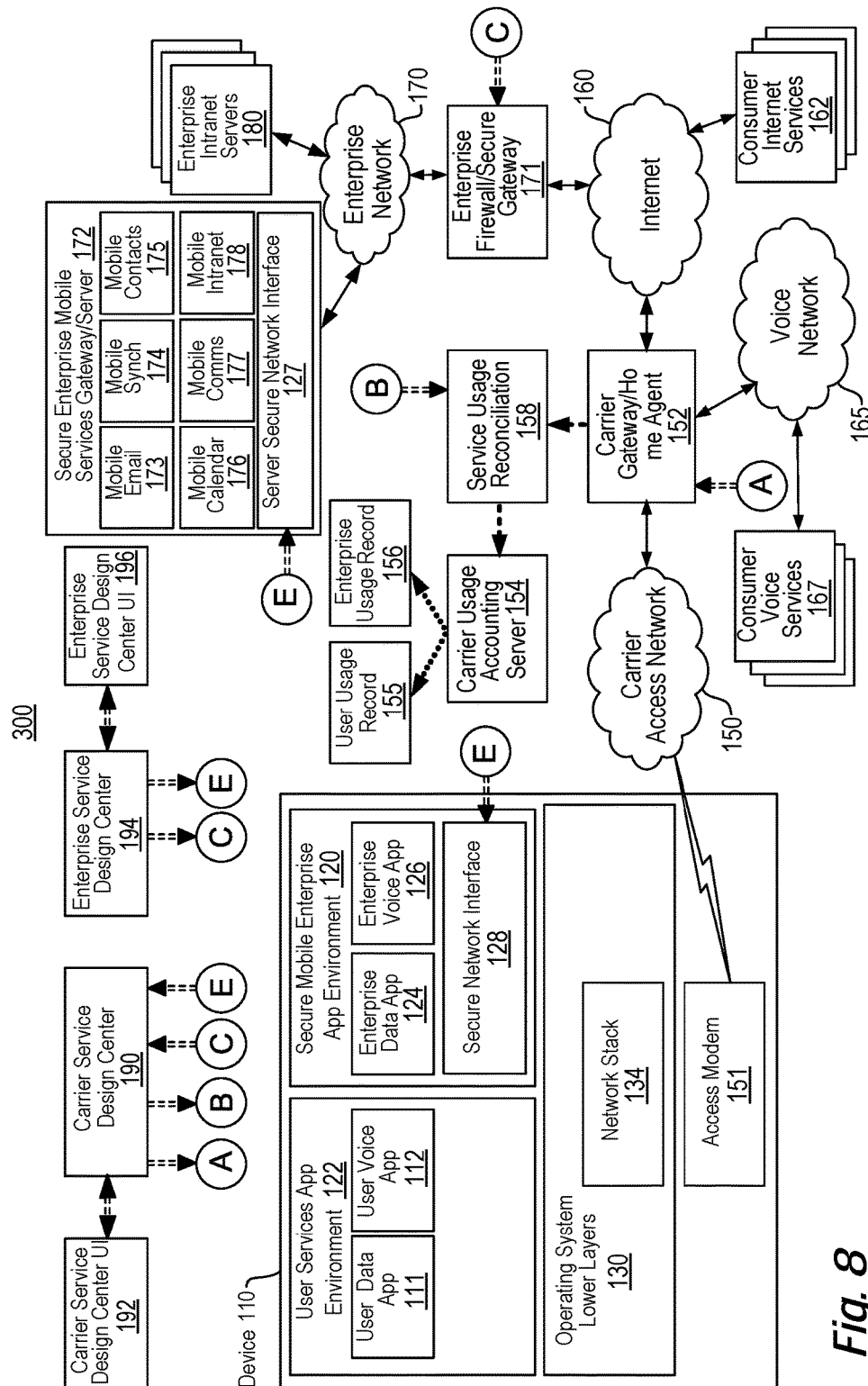


Fig. 7



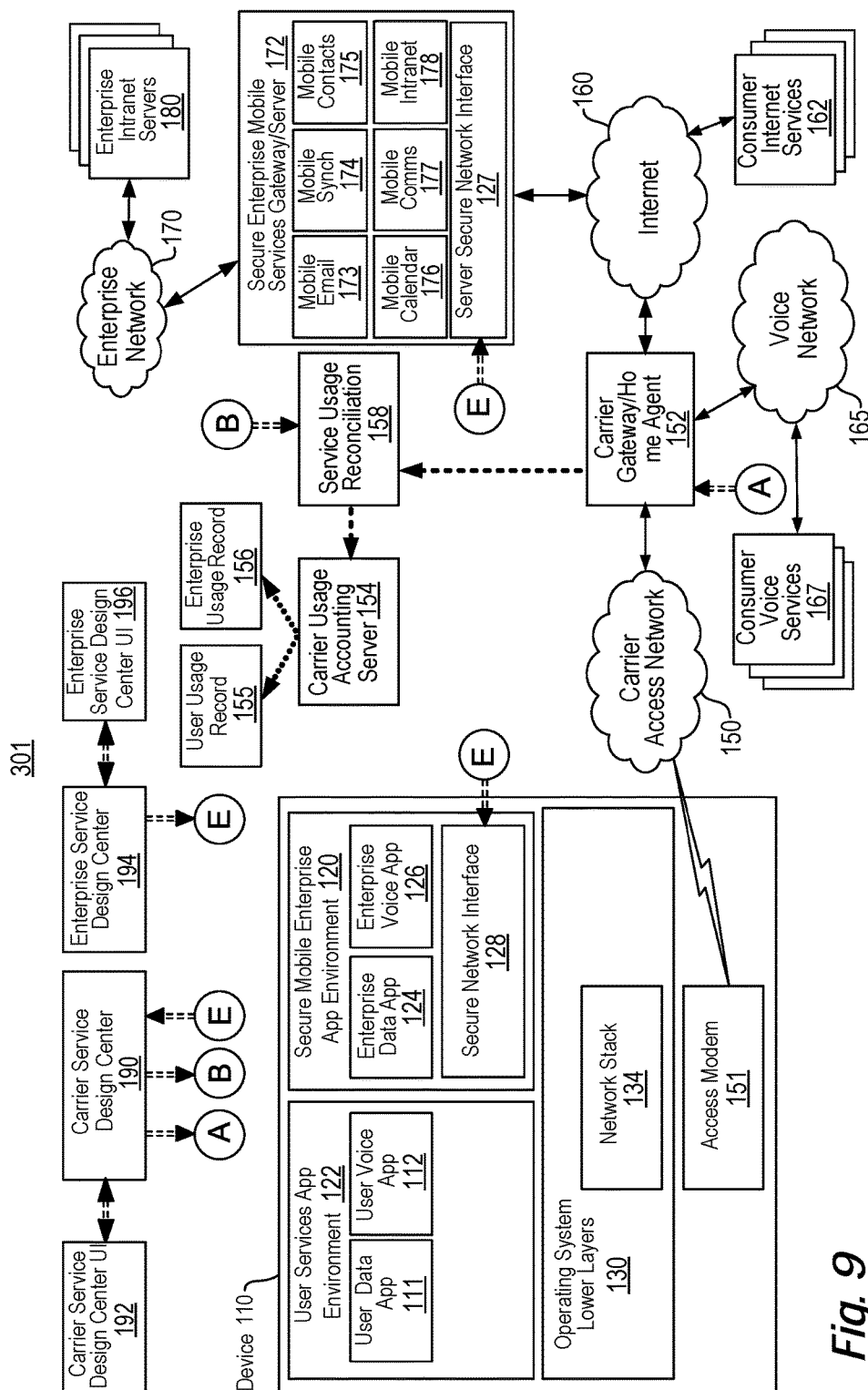


Fig. 9

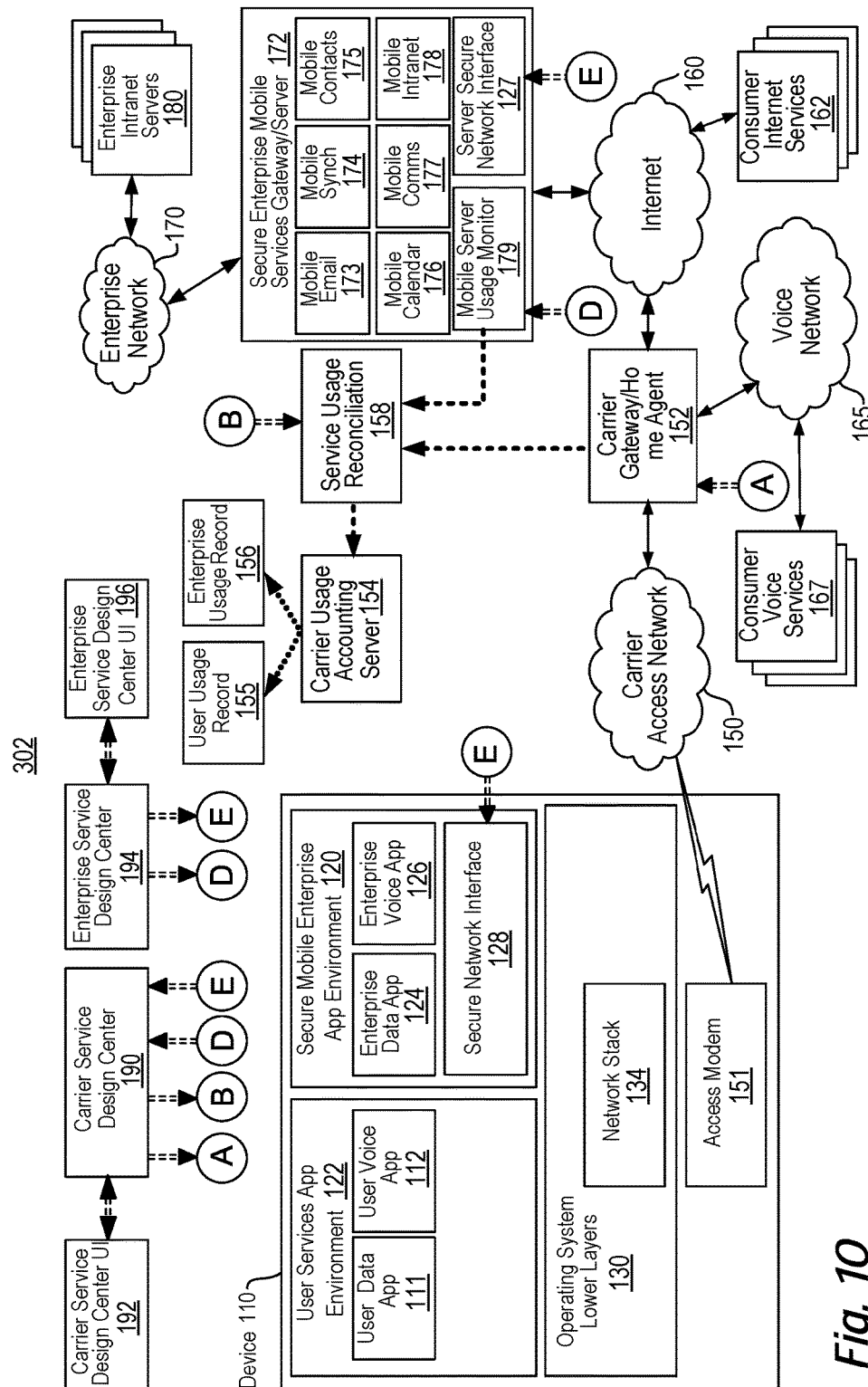


Fig. 10

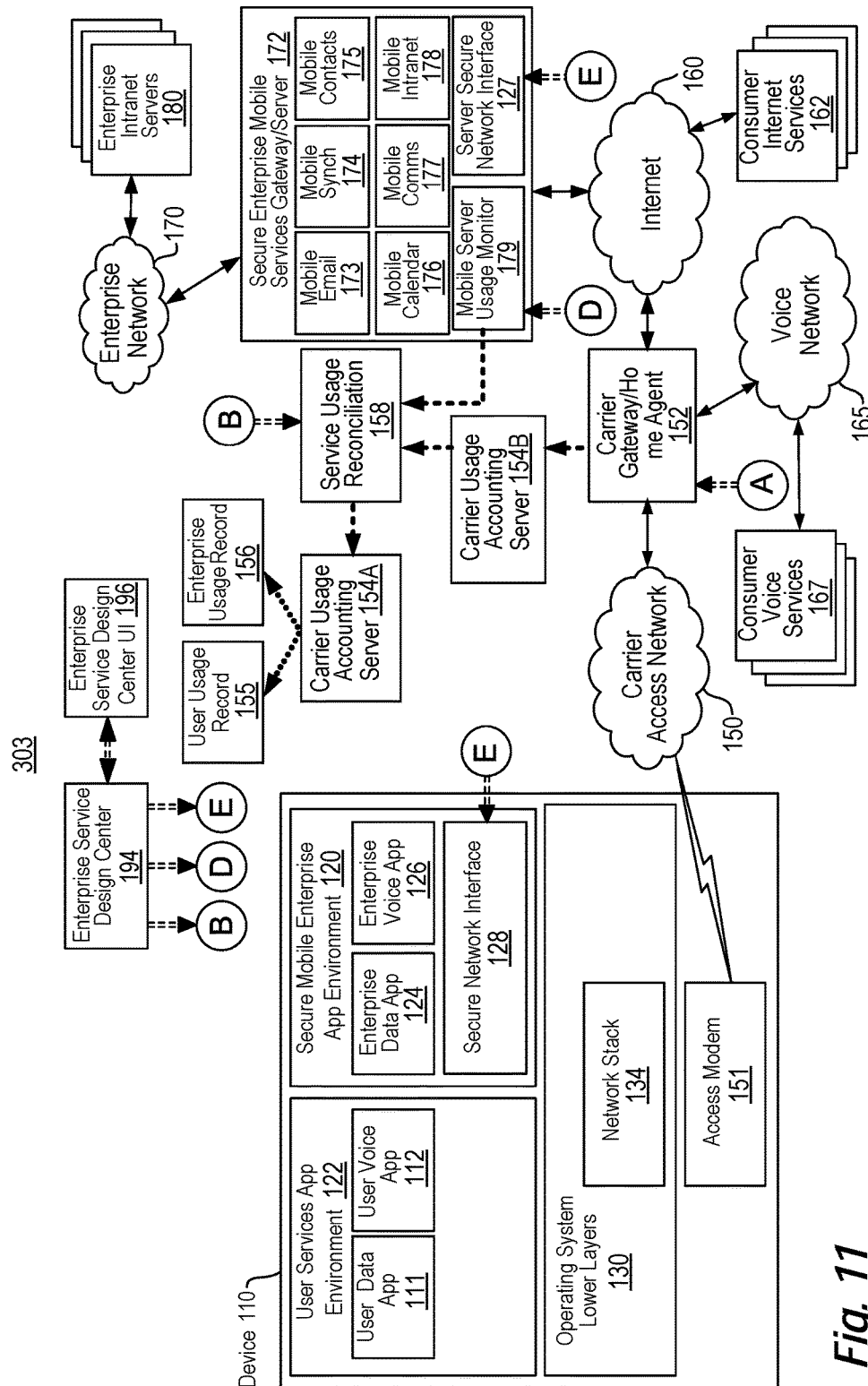


Fig. 11

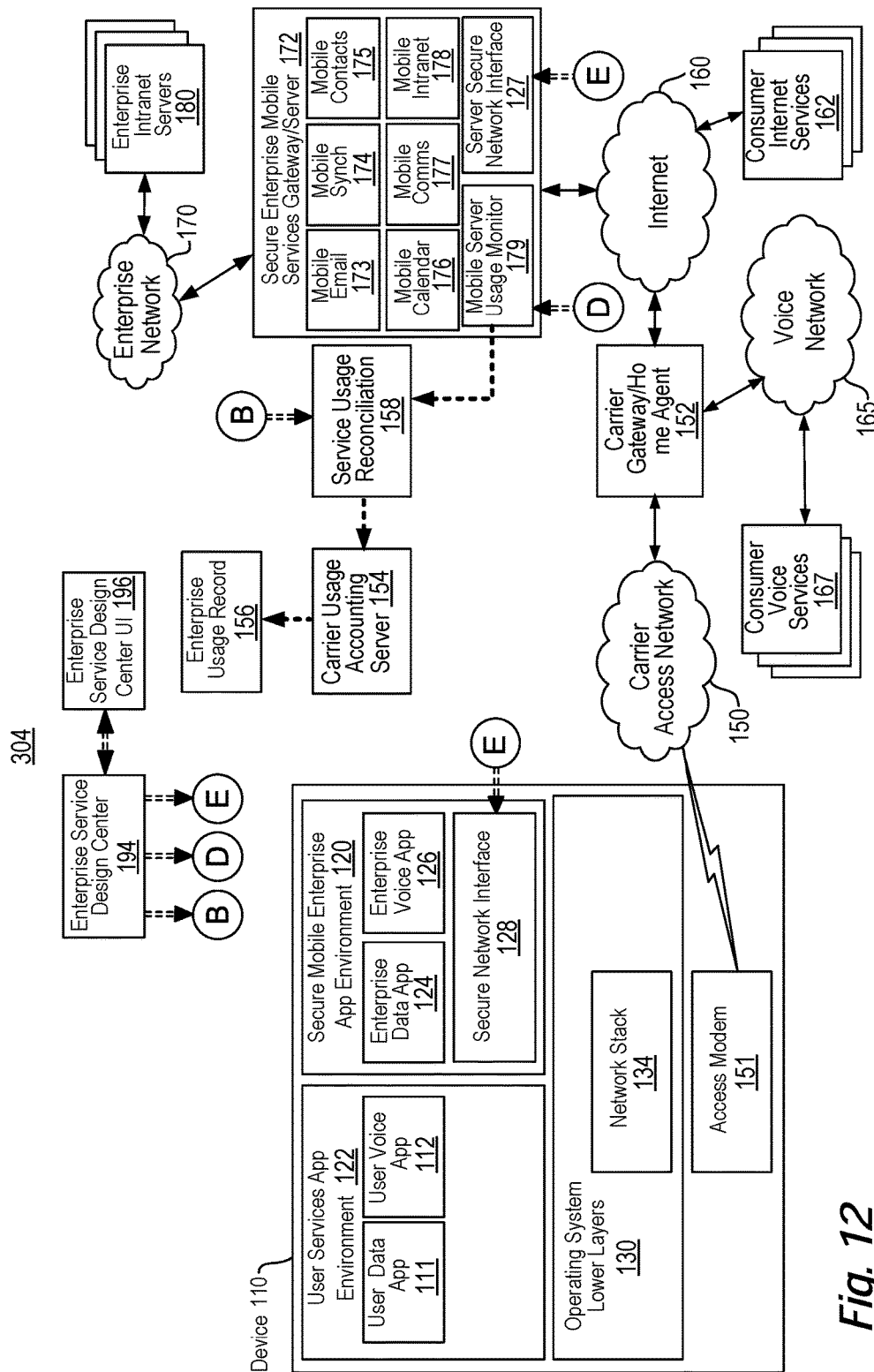


Fig. 12

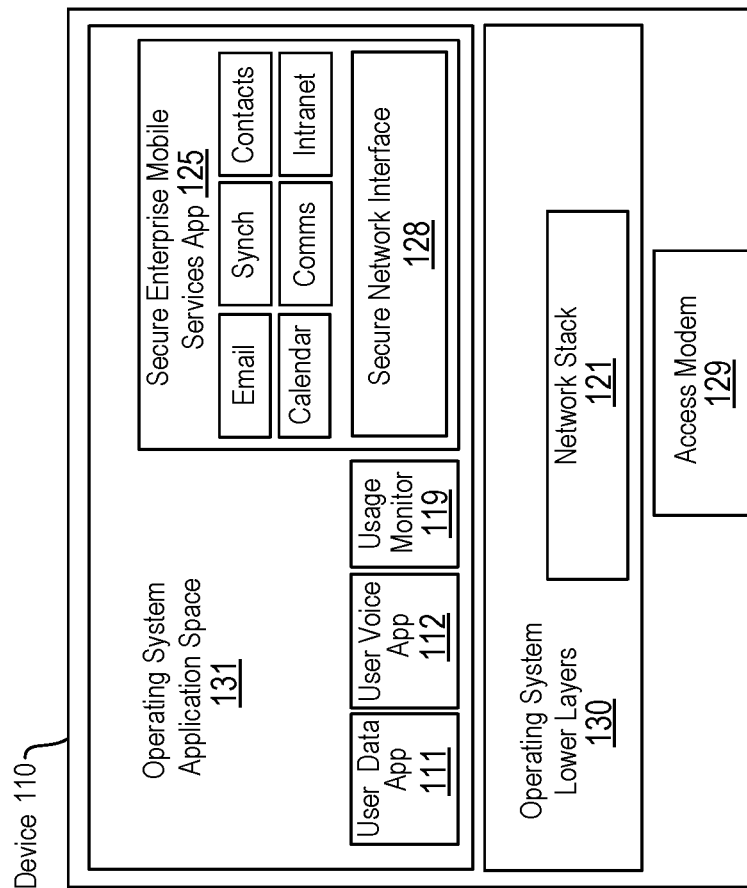


Fig. 13

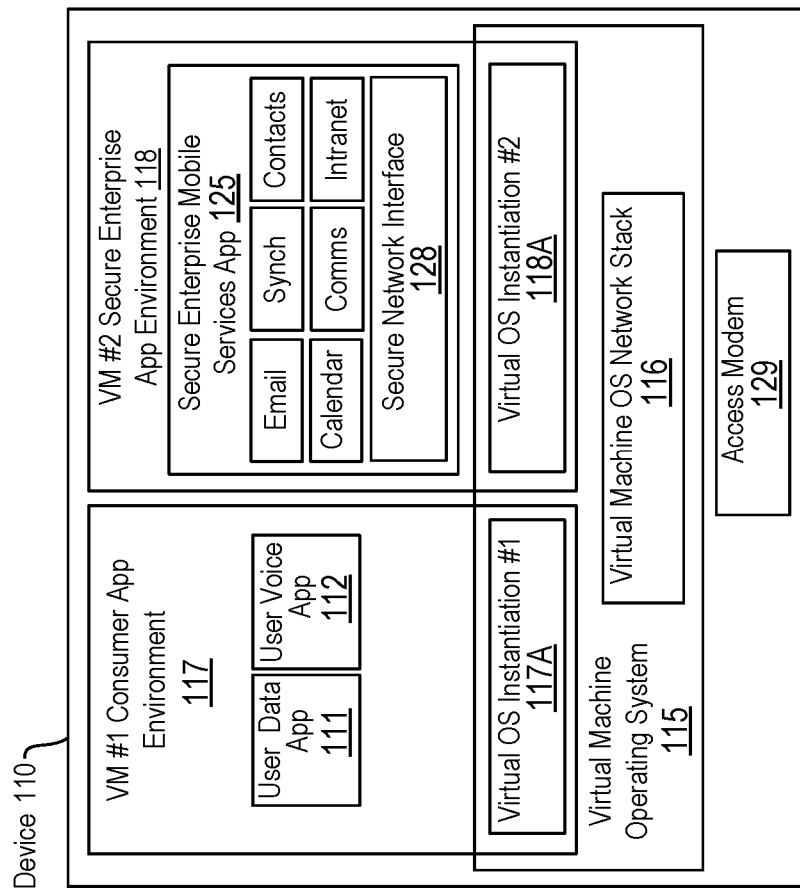


Fig. 14

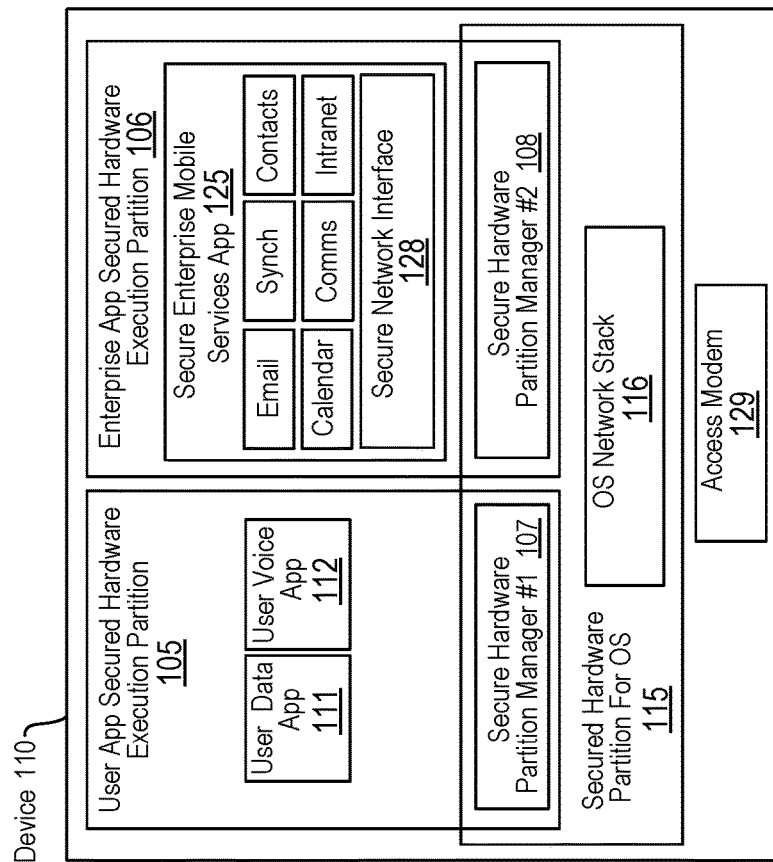


Fig. 15

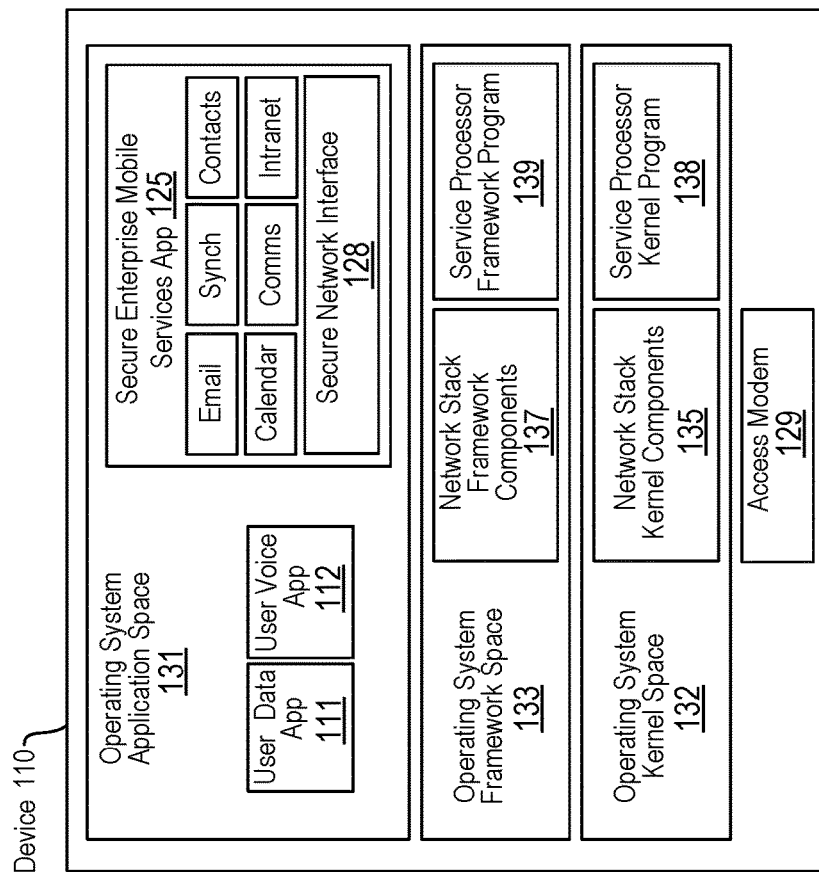
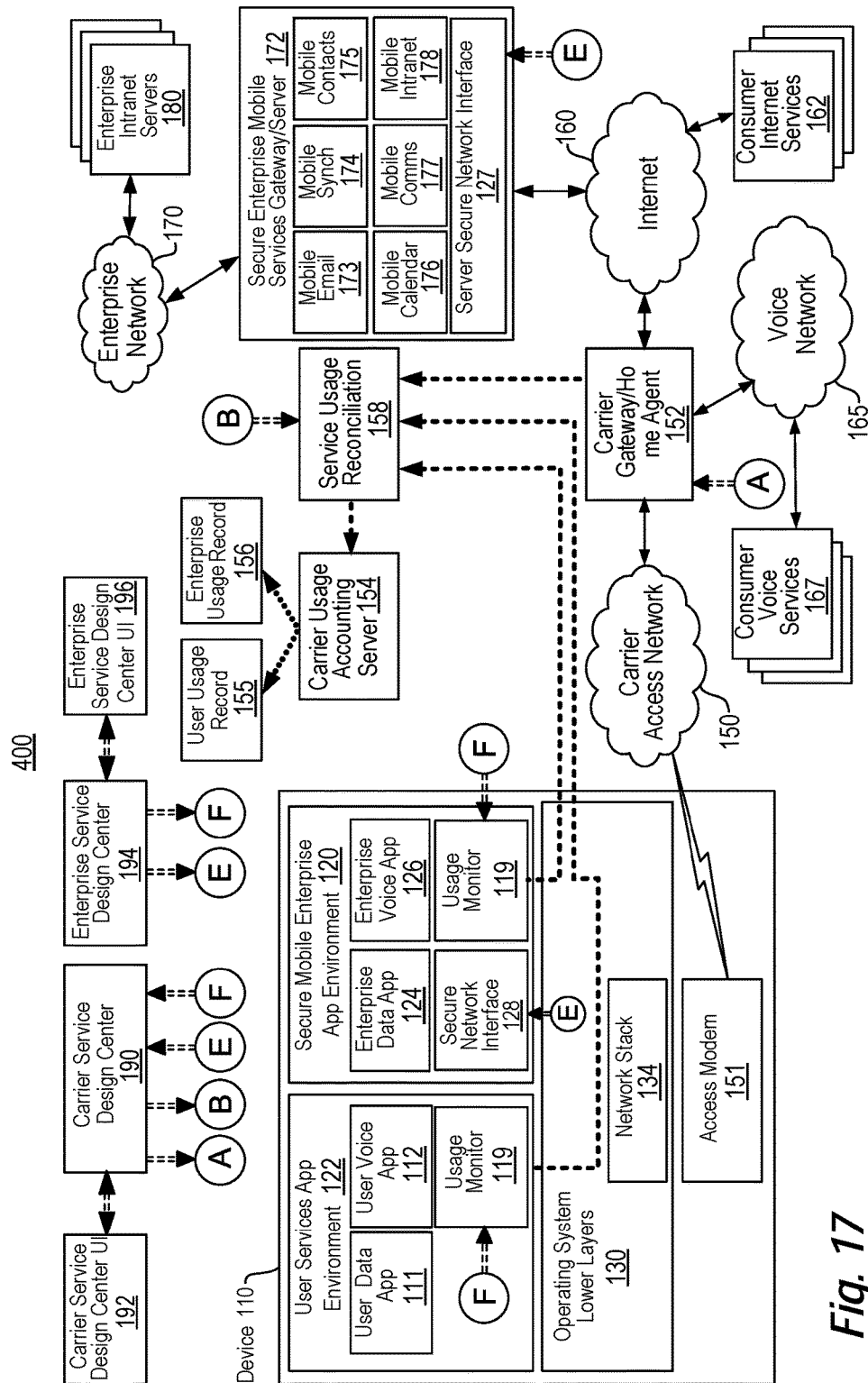


Fig. 16



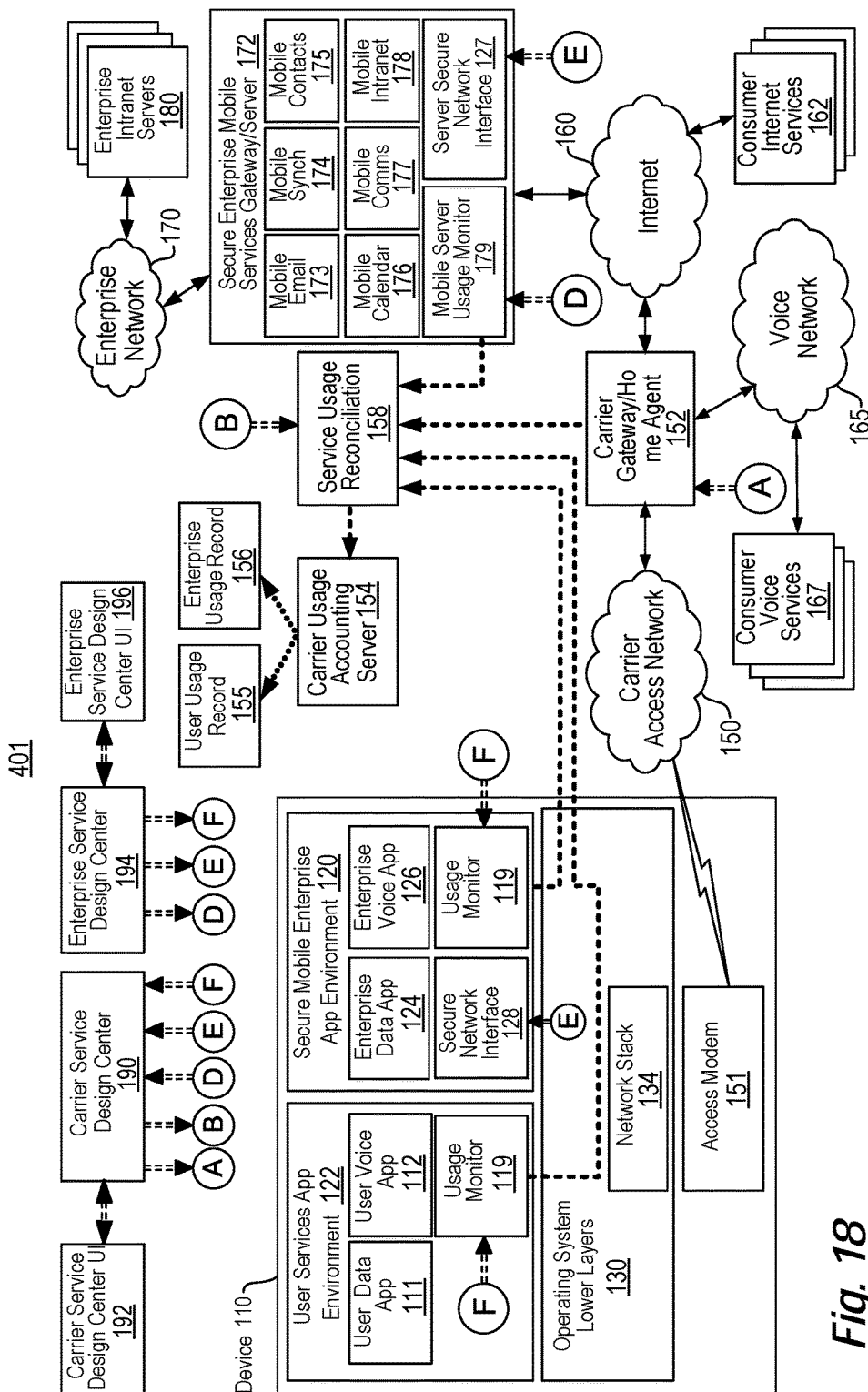


Fig. 18

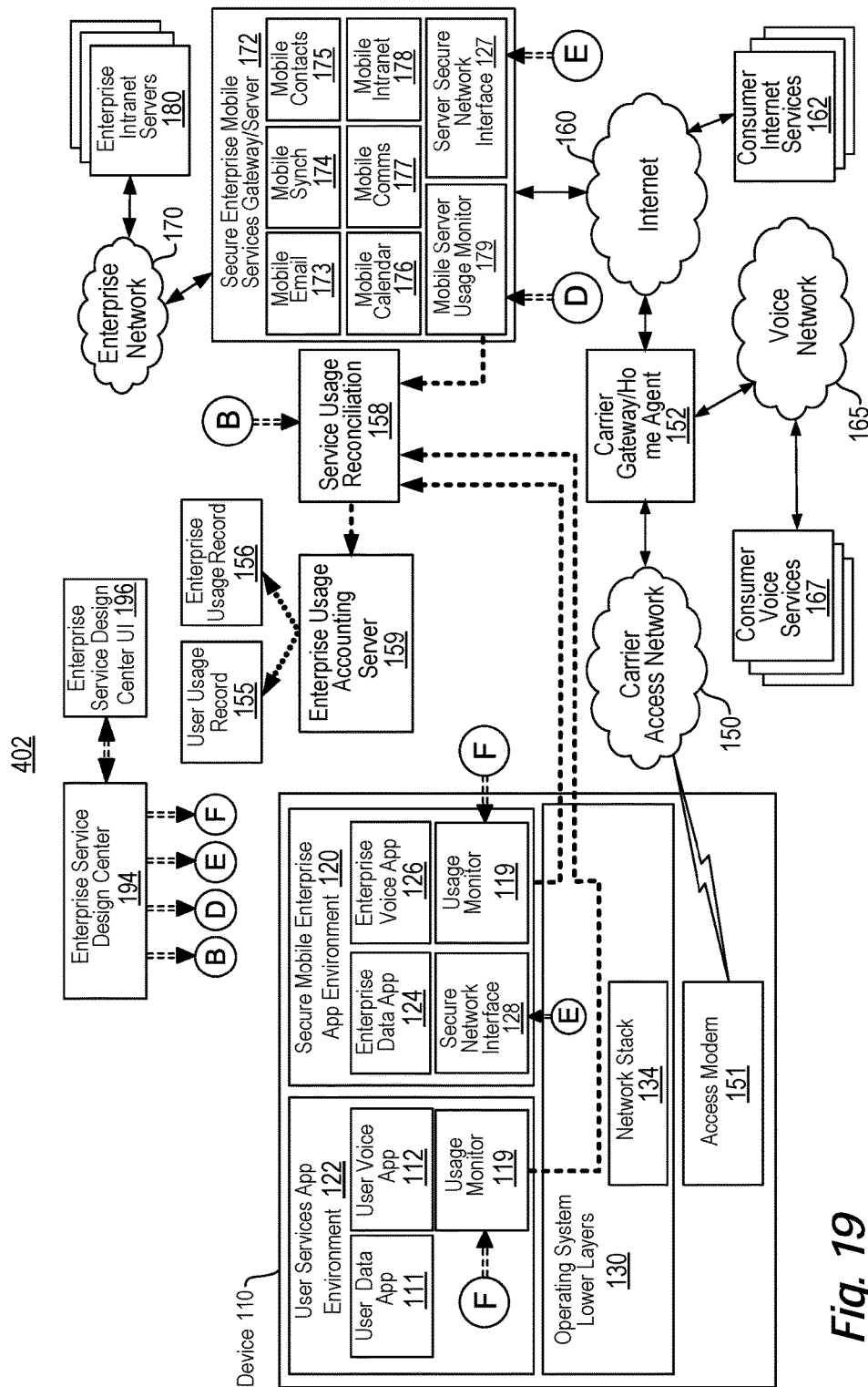


Fig. 19

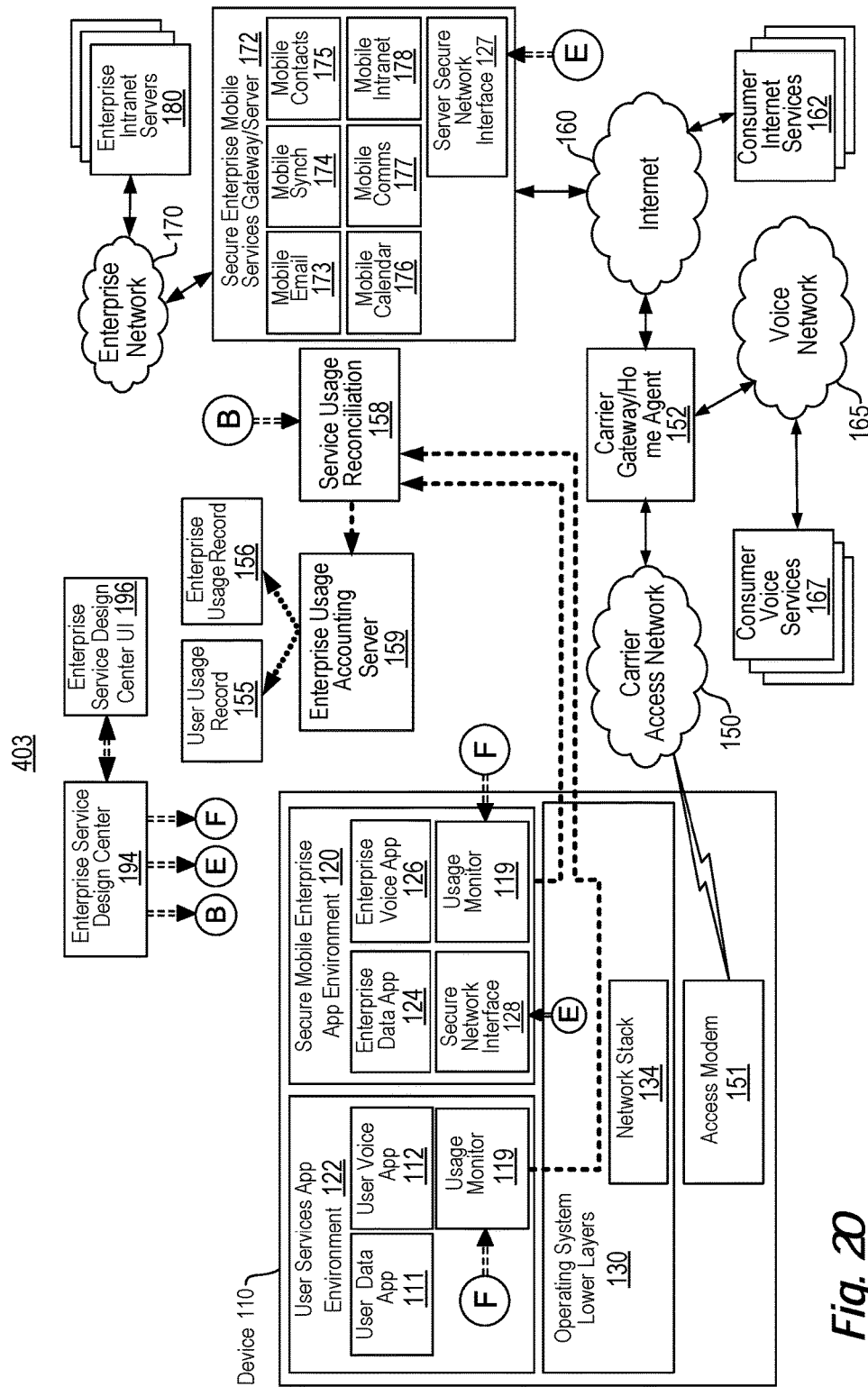
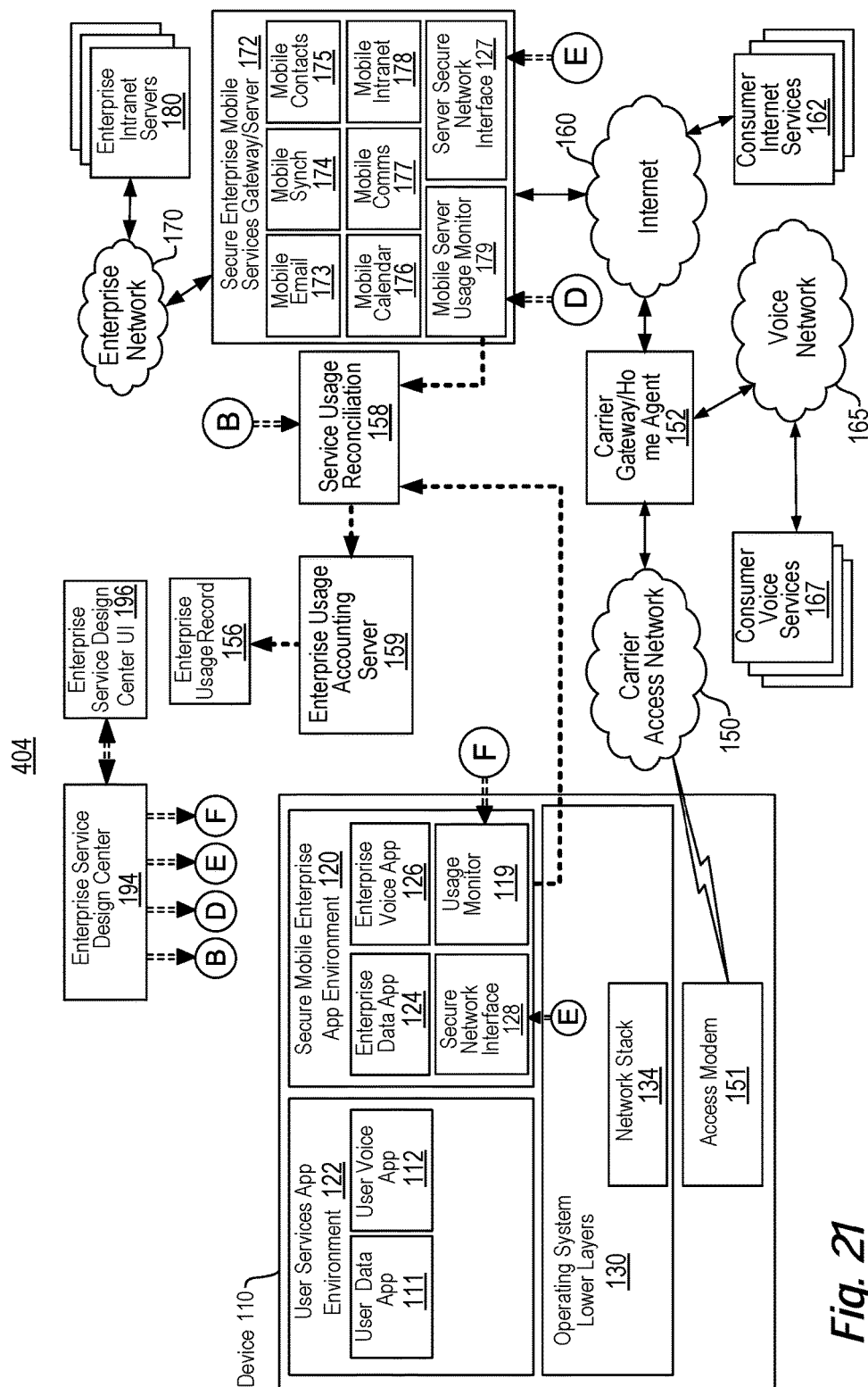


Fig. 20



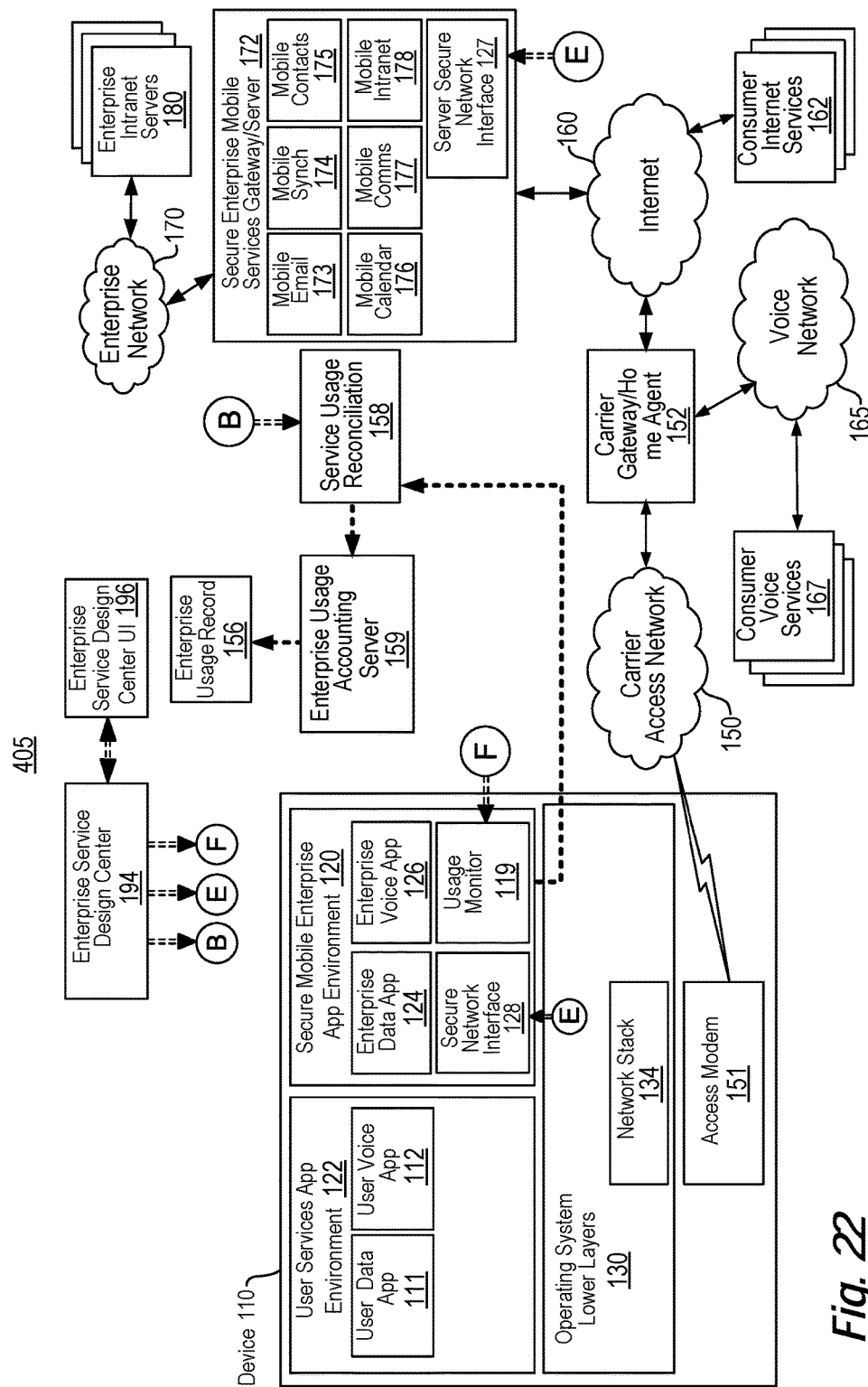


Fig. 22

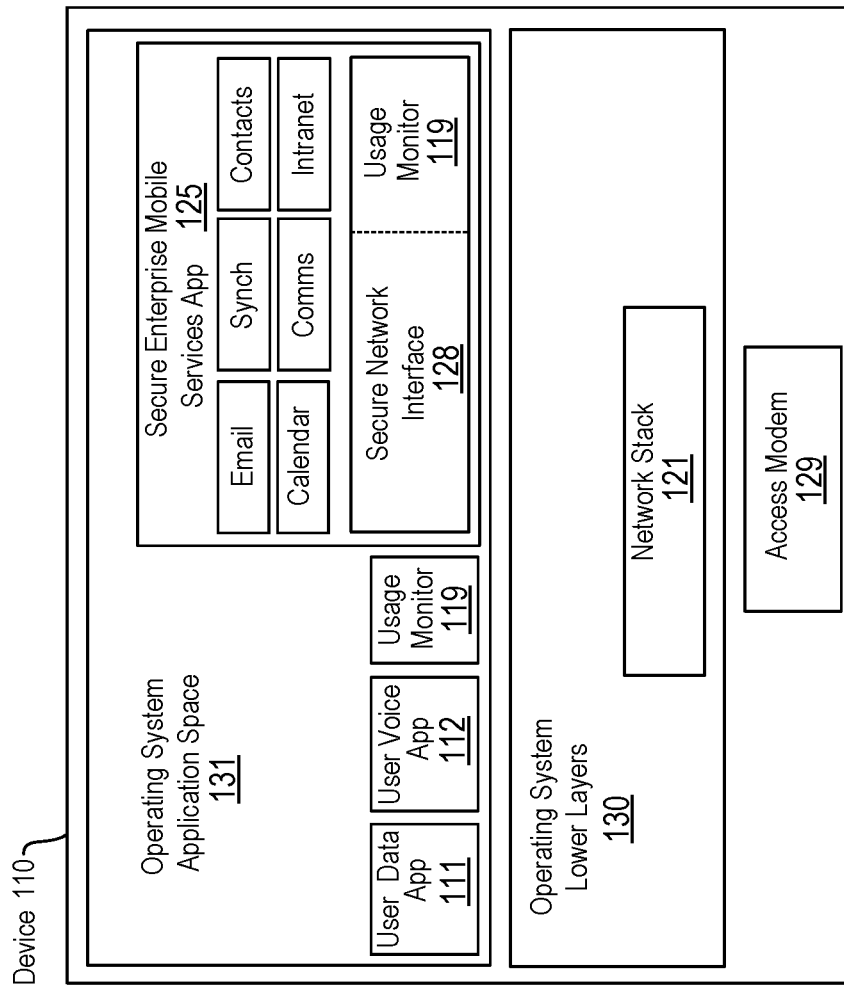


Fig. 23

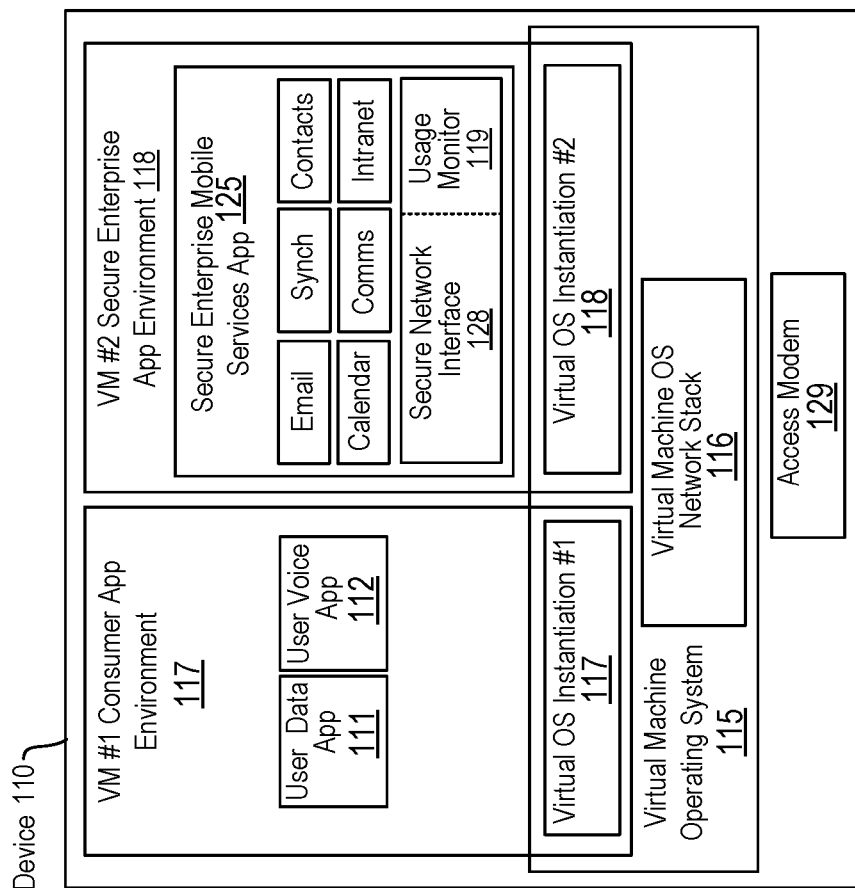


Fig. 24

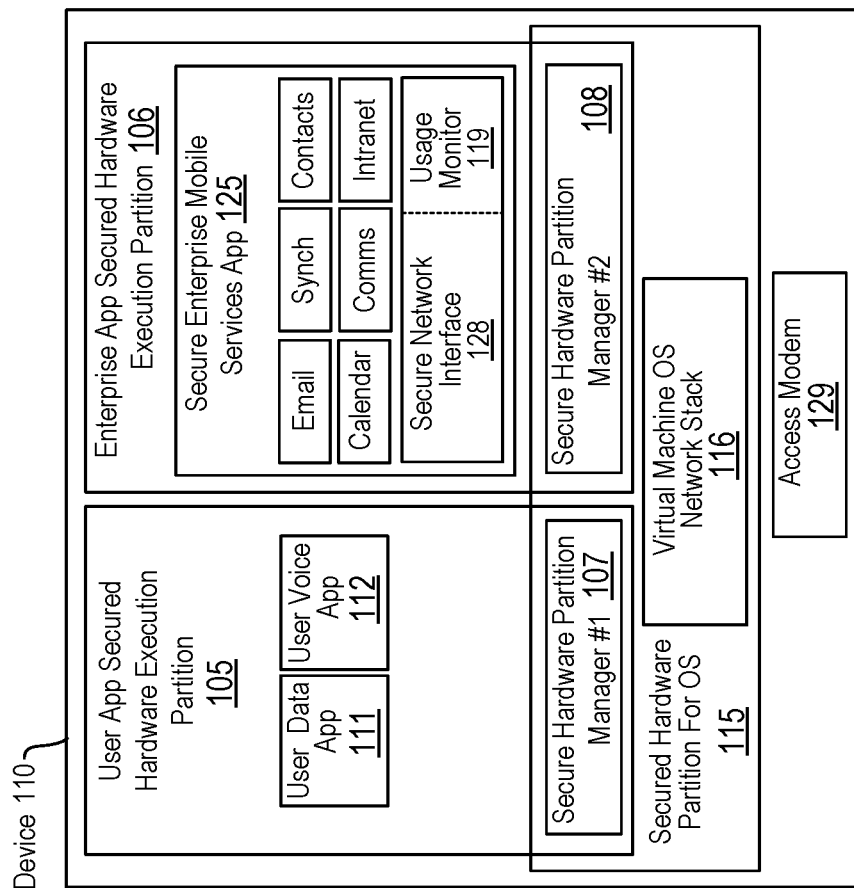


Fig. 25

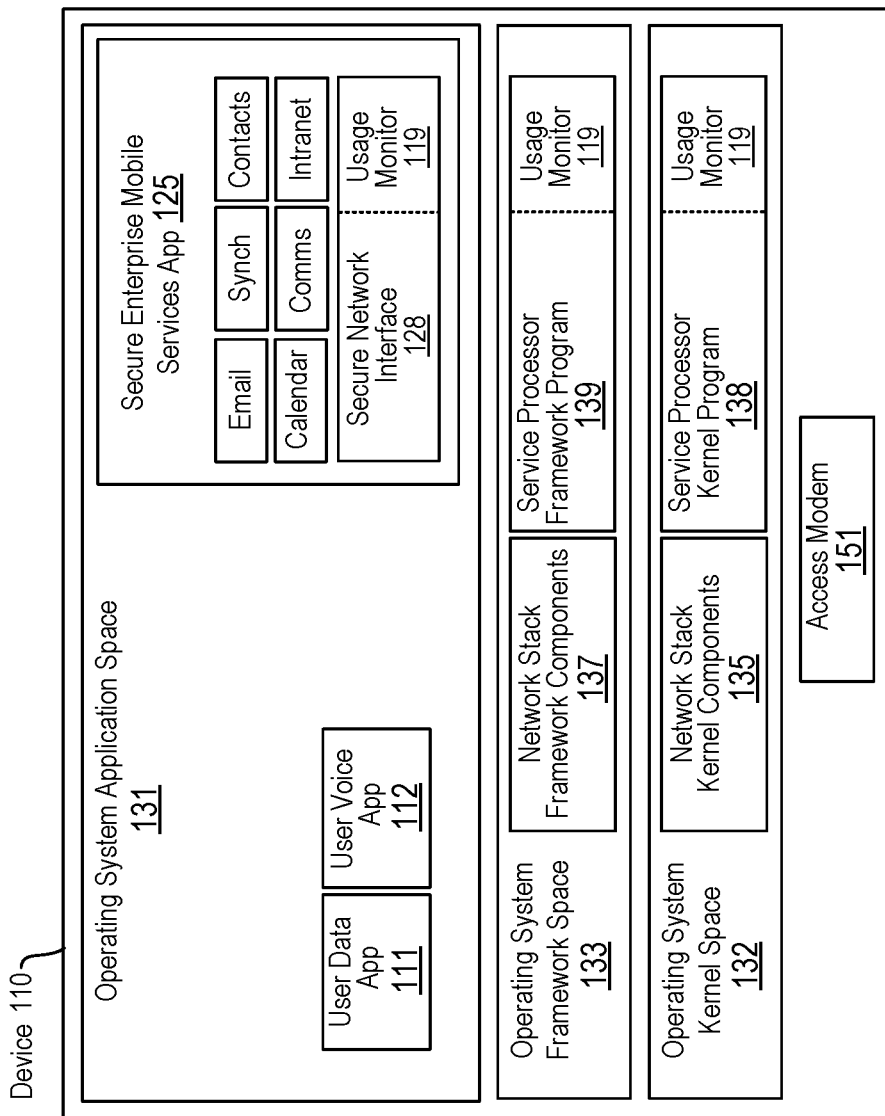
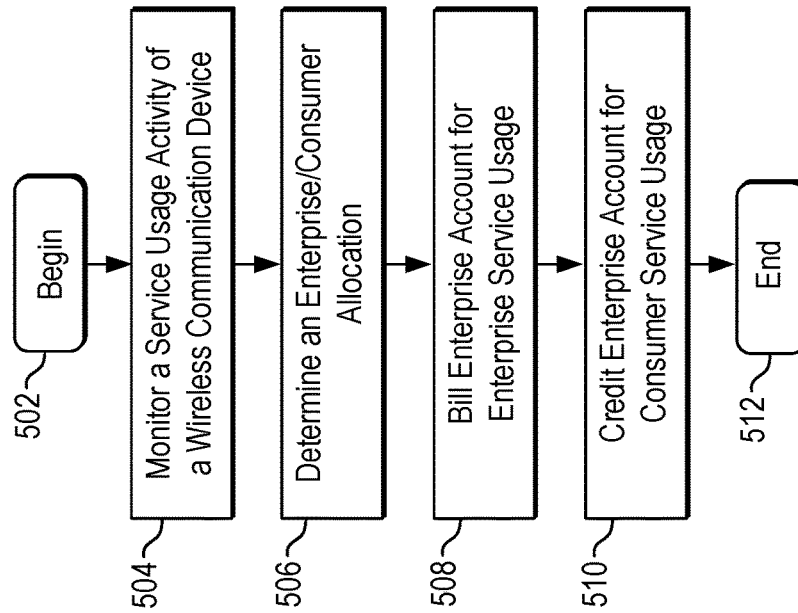
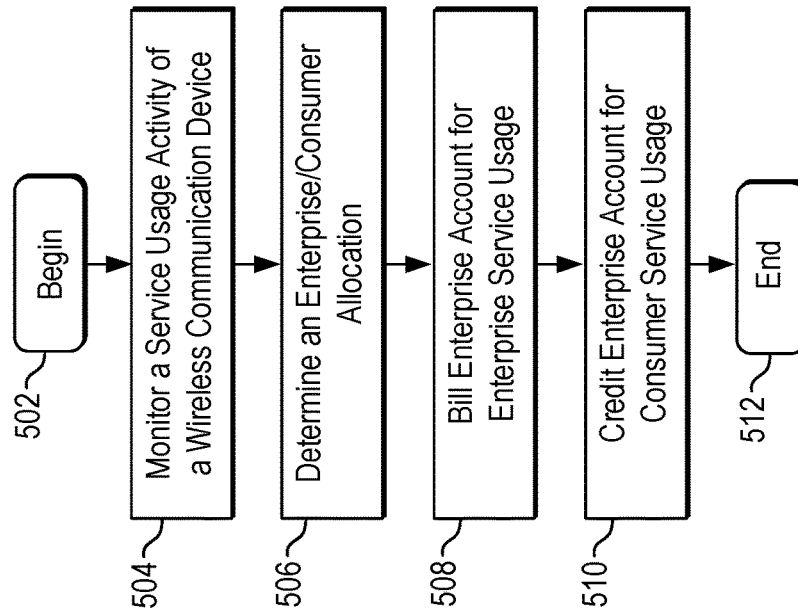
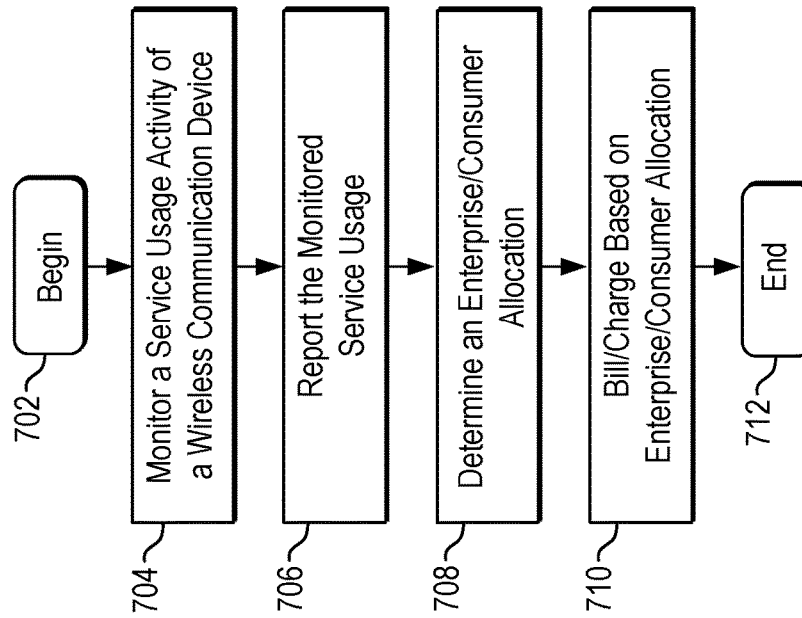
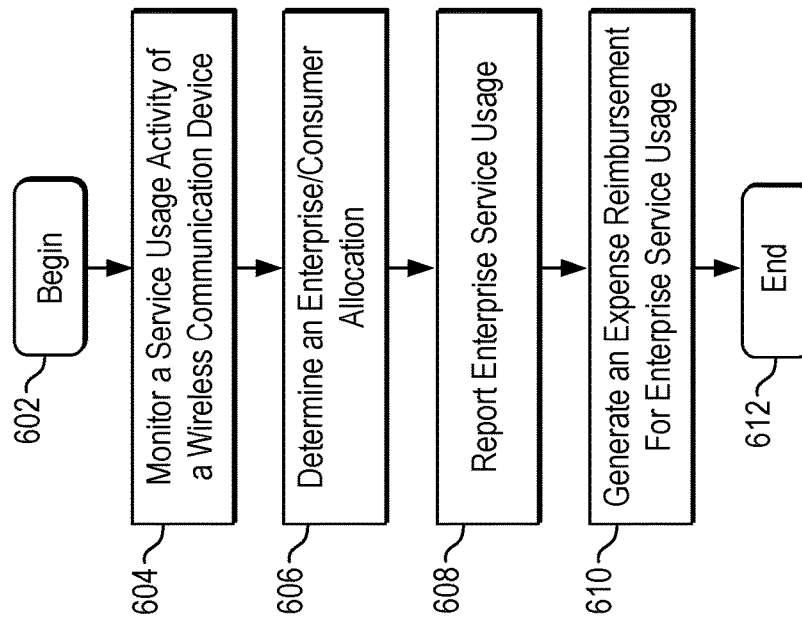


Fig. 26

*Fig. 27**Fig. 28*

*Fig. 30**Fig. 29*

ENTERPRISE ACCESS CONTROL AND ACCOUNTING ALLOCATION FOR ACCESS NETWORKS

BACKGROUND

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.

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

BRIEF DESCRIPTION OF THE DRAWINGS

Various embodiments of the invention are disclosed in the following detailed description and the accompanying drawings.

FIG. 1 illustrates a functional diagram of a network architecture for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 2 illustrates a functional diagram of another network architecture for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 3 illustrates a functional diagram of another network architecture for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 4 illustrates a functional diagram of another network architecture for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 5 illustrates a functional diagram of another network architecture for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 6 illustrates a functional diagram of another network architecture for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 7 illustrates a functional diagram of another network architecture for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 8 illustrates a functional diagram of another network architecture for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 9 illustrates a functional diagram of another network architecture for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 10 illustrates a functional diagram of another network architecture for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 11 illustrates a functional diagram of another network architecture for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 12 illustrates a functional diagram of another network architecture for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 13 illustrates a functional diagram of a secure device application architecture for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 14 illustrates a functional diagram of another secure device virtual machine architecture for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 15 illustrates a functional diagram of another secure device hardware execution partition architecture for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 16 illustrates a functional diagram of another secure device service processor architecture for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 17 illustrates a functional diagram of another network architecture for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 18 illustrates a functional diagram of another network architecture for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 19 illustrates a functional diagram of another network architecture for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 20 illustrates a functional diagram of another network architecture for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 21 illustrates a functional diagram of another network architecture for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 22 illustrates a functional diagram of another network architecture for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 23 illustrates a functional diagram of a secure device application architecture with device based service usage monitoring for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 24 illustrates a functional diagram of a secure device virtual machine architecture with device based service usage

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monitoring for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 25 illustrates a functional diagram of a secure device hardware execution partition architecture with device based service usage monitoring for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 26 illustrates a functional diagram of a secure device service processor architecture with device based service usage monitoring for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 27 illustrates a flow diagram for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 28 illustrates another flow diagram for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 29 illustrates another flow diagram for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

FIG. 30 illustrates another flow diagram for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments.

DETAILED DESCRIPTION

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.

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.

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Some enterprises only allow certain specialized wireless devices to be used for connection to their enterprise network. Such devices typically contain secure data storage and enterprise program execution environments to protect enterprise information and network access. This approach is generally directed towards maintaining enterprise data integrity and enterprise network security. However, this approach does not address the various problems associated with allocating service usage or billing between consumer or non-enterprise service usage activities and enterprise service usage activities.

Accordingly, there is a need to provide for an enterprise and consumer billing allocation for wireless communication device service usage activities. There is also a need to address various issues with enterprise policies that can vary from employee to employee. For example, roaming policies can be configured differently for a global sales person than for a finance administrator who does not travel as much on enterprise business. Furthermore, some enterprises may not elect to pay for employee wireless communication device purchase or all employee wireless communication service usage needs or desires. As a result, some enterprises would benefit from techniques that allowed such enterprises to piggy back on consumer device or service purchases while maintaining an enterprise and consumer billing allocation for wireless communication device service usage activities.

Also, some consumers prefer to select their own wireless communication device that may not be an enterprise approved wireless communication device or a specialized enterprise device specified by enterprise IT managers. For example, certain enterprises may only offer certain Blackberry smart phone devices, and certain employees may prefer Apple iPhone and/or various Android based smart phone devices. Another trend suggests that a growing number of enterprise employees desire to use a single wireless communication device for their enterprise mobile communication, enterprise information access, and enterprise network access as well as for, for example, their personal mobile communication, access, and application needs (e.g., consumer/personal, that is, non-enterprise, use of cellular calls, text messaging, web browsing, social networking, games, and various other service usage activities). Such dual persona devices, where a first persona is oriented to enterprise access and/or application needs and a second persona is oriented to personal access and/or application needs, are enabled by the disclosure herein.

As a result, enterprise network managers generally need a way to safely allow consumers to perform consumer mobile access services that the enterprise can specify that will not be paid for by the enterprise. Various network architectures and techniques are described herein that allow an enterprise to determine how much service usage (e.g., how much of a corresponding service bill) should be allocated to device user services or consumer services and how much should be allocated to enterprise services in which the enterprise sponsors the enterprise access. Various design approaches and techniques are described herein for allocating enterprise and consumer billing in a secure manner that works with both specialized enterprise wireless communication devices as well as other wireless communication devices. For example, crediting a user bill with sponsored enterprise service usage is provided using various techniques described herein. As another example, providing enterprise employee reimbursement for enterprise services used on the employee wireless communication device or allowing an enterprise to deduct employee consumer service usage from their paycheck is provided using various tech-

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niques described herein. As yet another example, allowing a consumer to select from an instant activation platform on a wireless communication device that comes pre-loaded with various enterprise services is provided using various techniques described herein. As yet a further example, providing for a capability to install or download an enterprise application that provides secure enterprise mobile services access and allocating enterprise and consumer billing for consumer wireless communication devices is provided using various techniques described herein.

Various techniques for monitoring service usage and providing for secured and verifiable device assisted services (DAS), including DAS based service usage monitoring, are disclosed in co-pending U.S. patent application Ser. No. 12/380,758, entitled VERIFIABLE DEVICE ASSISTED SERVICE USAGE MONITORING WITH REPORTING, SYNCHRONIZATION, AND NOTIFICATION, filed on Mar. 2, 2009, published as U.S. Pub. App. No. 20100191612, co-pending U.S. patent application Ser. No. 12/695,019, entitled DEVICE ASSISTED CDR CREATION, AGGREGATION, MEDIATION and BILLING, filed on Jan. 27, 2010, published as U.S. Pub. App. No. 20100197266, co-pending U.S. patent application Ser. No. 12/695,020, entitled ADAPTIVE AMBIENT SERVICES, filed on Jan. 27, 2010, published as U.S. Pub. App. No. 20100198698, co-pending U.S. patent application Ser. No. 12/694,445, entitled SECURITY TECHNIQUES FOR DEVICE ASSISTED SERVICES, filed on Jan. 27, 2010, published as U.S. Pub. App. No. 20100199325, co-pending U.S. patent application Ser. No. 12/694,451, entitled DEVICE GROUP PARTITIONS AND SETTLEMENT PLATFORM, filed on Jan. 27, 2010, published as U.S. Pub. App. No. 20100197267, which are incorporated herein by reference for all purposes.

In some embodiments, allocating enterprise and consumer billing for service usage activities on a wireless communication device is provided for service usage activities that an enterprise configures as approved and/or sponsored for enterprise billing (e.g., such service usage activities are paid for at least in part by the enterprise) and consumer applications and service usage activities that the device user chooses to use from the wireless communication device and that the enterprise does not sponsor. Various embodiments are disclosed herein describing a wide range of devices that users and enterprises may desire to use for such dual-purpose application scenarios. In some embodiments, devices for such applications can include a less specialized and secure device program execution environment as further described herein.

Accordingly, enterprise and consumer billing allocation for wireless communication device service usage activities is provided. In some embodiments, enterprise and consumer billing allocation for wireless communication device service usage activities includes monitoring a service usage activity of a wireless communication device (e.g., the monitoring can be performed in the wireless communication device and/or the monitoring of enterprise application service usage can be performed using a secure application server in the enterprise network), and determining an enterprise and consumer billing allocation for the monitored service usage activity. In some embodiments the allocation is determined by classifying the service usage activities as associated with a consumer service usage activity (e.g., in a consumer service usage activity list) or associated with an enterprise service usage activity (e.g., in an enterprise service usage activity list; or, as another example, if the monitored service usage activity is not included in the enterprise service usage

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activity list, then it can be automatically classified as a consumer service usage activity by default).

In some embodiments, enterprise and consumer billing allocation for wireless communication device service usage activities includes providing a service design center (SDC) for configuring an enterprise and consumer billing allocation of monitored service usage activities for a plurality of wireless communication devices associated with an enterprise account, and implementing the configured enterprise and consumer billing allocation for monitored service usage activities for the plurality of wireless communication devices associated with the enterprise account.

In some embodiments, enterprise and consumer billing allocation for wireless communication device service usage activities includes monitoring service usage of a wireless communication device, and determining whether a user is acting as a consumer (e.g., personal service usage activities on the wireless communication device) or a professional (e.g., enterprise service usage activities on the wireless communication device, that is, the user is working on the wireless communication device in his or her capacity as an employee for an enterprise, in which the wireless communication device is associated with an enterprise account for the enterprise) based on the monitored service usage activity (e.g., based on place, time of day, application or service activity, and/or other criteria or factors). In some embodiments, enterprise and consumer billing allocation for wireless communication device service usage activities differentially charges and/or allocates billing between the enterprise and the consumer based on a classification of the monitored service usage activity as allocated to the enterprise or to the consumer for billing/charging purposes. Such embodiments enable a dual persona device user experience.

In some embodiments, enterprise and consumer billing allocation for wireless communication device service usage activities includes monitoring a service usage activity of a wireless communication device, and reporting the monitored service usage activity to a network element (e.g., a service controller, a service usage reconciliation function, another service control or billing/charging function in the network, or another network element), in which the network element determines an enterprise and consumer billing allocation for the monitored service usage activity. In some embodiments, the network element (e.g., a service controller, a service usage reconciliation function, another service control or billing/charging function in the network, or another network element) determines an enterprise and consumer billing allocation for the monitored service usage activity. In some embodiments, a service usage reconciliation function determines how much service usage is due to enterprise service usage activities and how much is due to consumer service usage activities. In some embodiments, after determining the allocation between consumer and enterprise service usage activities, the service usage reconciliation function provides the information to a service usage accounting function (e.g., a carrier billing server or an enterprise service usage accounting server), which in turn delivers a consumer usage report or bill and/or an enterprise usage report or bill. In some embodiments, the service usage reconciliation function determines the amount of enterprise service usage and creates a service usage credit record so that a device user's account can be credited or a device user can be compensated or reimbursed for enterprise service usage costs. In some embodiments, a service usage monitor is configured to monitor service usage activities of a device. In some embodiments, the service usage monitor is configured to classify the monitored service usage activities as enterprise

service usage activities. In some embodiments, the service usage monitor is configured to classify the monitored service usage activities as consumer service usage activities. In some embodiments, the service usage monitor is configured to monitor a first group of service usage activities for service usage allocation to a device user (e.g., using a list of service usage activities associated with a consumer service usage), and a second group of service usage activities for service usage allocation to an enterprise (e.g., using a list of service usage activities associated with an enterprise service usage). In some embodiments, service usage activities (e.g., service activities, such as applications, network, and/or voice based activities that use wireless network service usage resources) are classified using various techniques described herein, such as based on application (e.g., application credential), device (e.g., device credential), time of day, network destination, network traffic protocol and/or port, and various other criteria/factors. In some embodiments, the service usage monitor is implemented in the network (e.g., on one or more network elements in the carrier network and/or enterprise network, as described herein). In some embodiments, the service usage monitor is implemented in the device (e.g., using various techniques described herein, including verifiable and/or secured device-based implementations). In some embodiments, the service usage monitor is implemented using both network-based and device-based techniques, as described herein with respect to various embodiments.

In some embodiments, a set of service activities that will be sponsored by an enterprise (e.g., a specified or configured list of enterprise sponsored service activities) is managed by an enterprise service design center. In some embodiments, a list of service activities and the associated service policies for each service activity are compiled to form an enterprise sponsored service activity policy set. For example, enterprise email, enterprise calendar, and enterprise contacts can be configured as sponsored service activities. In some embodiments, the sponsored enterprise services list includes a list of network destinations that are associated with the services (e.g., an enterprise mail server address and/or an enterprise internal corporate network). For example, the enterprise email can be a sponsored service that is associated with an enterprise sponsored email service policy, which can limit destinations for corporate email, sizes of emails and/or email attachments, and/or other email related usage criteria or factors (e.g., a service usage charging policy).

In some embodiments, the monitored service usage is reported to the reconciliation function by a carrier network service usage monitoring element (e.g., a home agent (HA), access network gateway, or other network element, such as a deep packet inspection (DPI) function). In some embodiments, the monitored service usage is reported to the reconciliation function by an enterprise network service usage monitoring element (e.g., a carrier network gateway or a mobile services gateway/server or other element in the enterprise network that can measure service usage and associate it with a given device credential or application credential). In some embodiments, the monitored service usage is reported to the reconciliation function by an element in the mobile device (e.g., a service usage monitor in a secure enterprise mobile services application or a Service Processor function, which can be securely implemented and/or verified using various techniques described herein).

In some embodiments, a service design center for implementing enterprise and consumer billing allocation for wireless communication device service usage activities is provided. For example, an enterprise manager can use the

service design center to select one or more services that the enterprise agrees to pay for/is responsible for paying for and to select one or more other services that the employees of the enterprise must agree to pay for/are responsible for paying for (e.g., if the employee elects to use/have such services that are not charged to the enterprise, or included as enterprise services that are charged to or paid for by the enterprise).

In some embodiments, a service design center that facilitates configuration of sponsored enterprise services for implementing enterprise and consumer billing allocation for wireless communication device service usage activities is provided. In some embodiments, a service design center for implementing enterprise and consumer billing allocation for wireless communication device service usage activities includes providing a service design center for a carrier network and another service design center for an enterprise network (e.g., in some cases, these service design centers can be combined).

In some embodiments, an enterprise sponsored service activity policy set is created by an enterprise network administrator through an enterprise service design center user interface (UI). In some embodiments, the enterprise sponsored service activity policy set includes a list of network destination addresses that corresponds to the desired sponsored service activity list, along with an access policy or service usage charging policy for the service activities. In some embodiments, all service activities in the enterprise sponsored service activity policy set receive the same access policies or charging policies. In some embodiments, a first subset of one or more of the service activities in the enterprise sponsored service activity policy set receive access policies or charging policies that are different than that of a second subset of service activities. For example, a sponsored enterprise email service can be in the first subset, and sponsored mobile voice services can be in the second subset, as certain employees (e.g., traveling sales personnel and/or executives) can be granted international and/or roaming mobile voice services, and other employees can be granted more limited sponsored mobile voice services.

In some embodiments, the enterprise network administrator uses the enterprise service design center to create an enterprise sponsored service device group list that includes device credentials or device application credentials that the carrier network and/or the enterprise network can use to identify a device or an application on a device as belonging to the group of devices for which the enterprise desires to sponsor enterprise service activities. In some embodiments, a sponsored service activity policy set is created by an enterprise network administrator through an enterprise service design center UI, and an enterprise sponsored service device group list is created by an enterprise network administrator through an enterprise service design center UI, and the two lists are stored in the enterprise service design center in which they are associated with one another for the purpose of provisioning the carrier network, the enterprise network, and/or the devices to provide the desired enterprise sponsored services policy set to the enterprise sponsored services device group, as described herein with respect to various embodiments.

In some embodiments, the association between an enterprise sponsored services device group and an enterprise sponsored service policy set is used by a service design center to create a provisioning table, in which the provisioning table is a list of the provisioning programming required for the various carrier network elements, enterprise network elements, and/or device elements to implement the

desired sponsored service activity policy set for the enterprise sponsored services device group.

For example, an enterprise can use the service design center to configure certain destinations/services as enterprise services or potentially enterprise services based on various factors (e.g., corporate sites, corporate email/email servers, corporate web pages/intranet, and can, for example, agree to pay for a certain level of general web browsing by usage/time of day and/or other factors, corporate contacts/calendars, corporate videoconferencing; and certain applications, such as web conferencing applications or other applications; certain telephone service usages, etc.). As another example, the service design center can present a configuration interface that allows users to select from one or more service plans that include various consumer and enterprise allocations and/or to select an enterprise only service plan.

In some embodiments, the service design center specifies one or more service plans the device user can select from and these service plan selection options are configured into a configuration interface on a device software application that allows users to select from one or more service plans that includes various consumer and enterprise allocations and/or to select an enterprise only service plan. In some embodiments, the configuration interface is made available directly on the device via a device client that provides a service plan selection user interface that displays one or more service plan options configured in the service design center or the enterprise service design center. In some embodiments, the configuration interface is presented directly on a device user interface (UI) when the user attempts to use an access service usage activity that requires a service plan to be activated or purchased. In some embodiments, the configuration interface presented via the device UI accepts a user response, transmits it to a carrier network element responsible for provisioning a new user service plan that in turn activates the service plan chosen by the user, possibly after confirming service payment credit for the user or enterprise entity. In some embodiments, the carrier network element responsible for provisioning a new user service plan is a carrier usage accounting server. In some embodiments, the carrier network element responsible for provisioning a new user service plan is a consumer internet services element. In some embodiments, the carrier network element responsible for provisioning a new user service plan is a carrier gateway or home agent. In some embodiments the carrier network element responsible for provisioning a new user service plan is a billing system or service plan provisioning system. In some embodiments, the configuration interface is made available to the user in the form of a web site that provides a service plan selection user interface that displays one or more service plan options configured in the service design center or the enterprise service design center.

In some embodiments, the initial configuration of the end-user device includes one or more enterprise access service plans that allow the user to access certain applications or network destinations associated with enterprise access services, and the user can choose from one or more additional consumer oriented service plans offered directly on the device UI by a device software application in communication with a carrier network element responsible for provisioning a new user service plan that in turn activates the service plan chosen by the user, possibly after confirming service payment credit for the user or enterprise entity. In some embodiments, these access service plan options are configured with a service design center. In some embodi-

ments, these access service plan options are configured with an enterprise service design center.

In some embodiments, enterprise data locally stored on the wireless communication device is secured and access to an enterprise network from the wireless communication device is secured so that only authorized devices or applications can access the network. In some embodiments, security for enterprise data and network access is accomplished by connecting the wireless communication device to the enterprise network via a secure mobile services application on the wireless communication device that connects via a secure channel to a secure mobile services gateway server in the enterprise network. In some embodiments, the SDC is programmed to provision the network and/or device apparatus to detect service usage communication with the mobile services gateway server and record that as a usage charge for network services. In some embodiments, such service usage communication with the mobile services gateway server is credited to the user's carrier account or used as a reimbursement to the user bill.

In some embodiments, determining the enterprise and consumer billing allocation for wireless communication device service usage activities is performed using a classifier implemented on the wireless communication device that classifies the monitored service usage activity (e.g., service usage can also be measured by the classifier and/or another function implemented on the wireless communication device, which can similarly be implemented in a secure execution area or in a secure memory), in which the classifier is executed in a secure execution area or a secure memory of the wireless communication device. In some embodiments, the security of the classifier is verified, periodically or at other times, using various techniques, such as by comparing a local service usage measure with a network based service usage measure and/or comparing a secured local service usage measure with another local service usage measure. In some embodiments, a secured application protects one or more enterprise applications (e.g., email, calendar, contacts, intranet access, and/or other enterprise specified applications, such as applications configured as approved or authorized enterprise applications for a particular enterprise by an enterprise manager using a service design center) from unauthorized use or tampering.

In some embodiments, the secure mobile services application also provides for usage monitoring of the enterprise service usage of the device. In some embodiments, the secure mobile services application also provides for service access control for the enterprise services of the device so that enterprise network access policies can be locally enforced on the device.

In some embodiments, security for enterprise data and network access is provided by connecting to the enterprise network via a secure mobile services application executed securely (e.g., in a virtual machine or in a hardware secured execution partition) on the wireless communications device that connects via a secure channel to a secure mobile services gateway server in the enterprise network. In some embodiments, security for enterprise data and network access is provided by connecting to the enterprise network via a secure mobile services application executed on a wireless communications device that includes a service processor, as described herein, that connects via a secure channel to a secure mobile services gateway server in the enterprise network. In some embodiments, the SDC is programmed to provision the network and/or wireless communications device apparatus to detect service usage communication with the mobile services gateway server, and

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record that as a usage charge for network services. In some embodiments, such service usage communication with the mobile services gateway server is credited to the user's carrier account or used as a reimbursement to the user bill.

In some embodiments, the service processor also provides for service usage monitoring of the enterprise service usage of the device, as described herein with respect to various embodiments. In some embodiments, the service processor also provides for service access control for the enterprise services of the device so that enterprise network access policies can be enforced on the device, as described herein with respect to various embodiments.

In some embodiments, enterprise and consumer billing allocation for wireless communication device service usage activities includes associating the wireless communication device and/or an authorized user of the wireless communication device (e.g., using device/user credentials) with an enterprise account (and, in some embodiments, a consumer account), associating an application with a service, and associating the service with the enterprise account (e.g., a service for the wireless communication device that the enterprise agreed to pay for). In some embodiments, enterprise and consumer billing allocation for wireless communication device service usage activities further includes using application-based monitoring and/or control using, for example, device assisted services.

In some embodiments, enterprise and consumer billing allocation for wireless communication device service usage activities includes crediting an associated consumer account for service usage allocated to an enterprise account. In some embodiments, enterprise and consumer billing allocation for wireless communication device service usage activities includes billing the enterprise for service usage allocated to the enterprise account. In some embodiments, enterprise and consumer billing allocation for wireless communication device service usage activities includes reporting to the enterprise (and, in some embodiments, the consumer) service usage allocated to the enterprise account, and the enterprise can, for example, provide an expense reimbursement to the consumer (e.g., employee, partner, associate, or contractor of the enterprise).

In some embodiments, enterprise and consumer billing allocation for wireless communication device service usage activities includes associating the wireless communication device with an enterprise account and a consumer account, associating an application with a service, and associating the service with the consumer account (e.g., a service for the wireless communication device that the consumer, such as an employee of the enterprise, agreed to personally pay for). In some embodiments, enterprise and consumer billing allocation for wireless communication device service usage activities further includes using application-based monitoring and/or control using, for example, device assisted services.

In some embodiments, enterprise and consumer billing allocation for wireless communication device service usage activities includes crediting an associated enterprise account for service usage allocated to a consumer account. In some embodiments, enterprise and consumer billing allocation for wireless communication device service usage activities includes billing the consumer for service usage allocated to the consumer account. In some embodiments, enterprise and consumer billing allocation for wireless communication device service usage activities includes reporting to the enterprise (and, in some embodiments, the consumer) service usage allocated to the consumer account, and the

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enterprise can, for example, deduct the cost for such service usage as an expense from the consumer's periodic/next paycheck.

In some embodiments, enterprise and consumer billing allocation for wireless communication device service usage activities does not require a network element or a device element to control services. For example, a user with a device associated with a bulk service usage plan can be automatically credited for sponsored enterprise service usage. If the bulk service usage plan has a service plan cap associated with the user's consumer service plan, then the service usage classified as sponsored enterprise service usage can be deducted from the total service usage such that the sponsored enterprise service usage does not count towards the user's capped consumer service plan usage. As another example, an enterprise account associated with the wireless communication device and/or user can allow the user to exceed a monthly or other service plan cap for sponsored enterprise service usage (e.g., based on various criteria and/or other factors, such as a more restrictive enterprise service policy to avoid potential misuse of sponsored enterprise services for personal use).

In some embodiments, enterprise and consumer billing allocation for wireless communication device service usage activities is provided using network-based and/or device-based techniques as described herein with respect to various embodiments. For example, using various techniques described herein, an enterprise manager can control the services for wireless communication devices for the enterprise, including access to such services and/or charging for such services (e.g., services used by employees in which some are charged to the enterprise on behalf of the employee and some are charged to the employee as a consumer of such services) and user notification messages. For example, the enterprise manager or another network element/function can cap and/or control service usage for consumer services and/or enterprise services.

In some embodiments, a service usage reconciliation function is provided. In some embodiments, the service usage reconciliation function implements the rules for a billing split for the enterprise and consumer billing allocation for wireless communication device service usage activities, as described herein with respect to various embodiments. In some embodiments, the service usage reconciliation function also facilitates fraud detection, as described herein with respect to various embodiments.

Carrier Managed Billing Allocation with Service Usage Monitoring in Carrier Network

FIG. 1 illustrates a functional diagram of a network architecture **100** for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. In some embodiments, a wireless communication device **110** includes a memory, an application processor (e.g., or more than one application processor or general processor), and a wireless modem, shown as an access modem **151**. As shown, the wireless communication device **110** includes an operating system application space **131** for executing applications and communicating wirelessly using operating system lower layers **130**, network stack **136**, and the access modem **151**. As used herein, application space refers to a portion of memory and a portion of a processor operating system execution environment for executing application programs. As also shown, the wireless communications device **110** includes operating system lower layers **130**. As used herein, operating system lower layers refers to one or more OS layers that typically implement networking functions (e.g.,

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network stack 136). In some embodiments, operating system lower layers 130 is where certain application data and communications security functions are implemented as described herein. In some embodiments, operating system lower layers 130 is where certain service usage monitoring and reporting functions are implemented as described herein. In some embodiments, operating system application space 131 executes various user applications, including one or more of user data application 111 and user voice application 112, and various enterprise applications, including enterprise data application 124 and enterprise voice application 126. In some embodiments, the execution environment for user applications and enterprise applications is the same (e.g., as shown in FIGS. 1 through 7). For example, a consumer Internet browser can execute in the operating system application space 131 for providing Internet web site browsing or web based email service via network stack 136 and wireless access modem 151 (e.g., a wireless modem), and an enterprise email program can also execute in the operating system application space 131 to communicate with an enterprise email server also via network stack 136 and wireless access modem 151. In some embodiments, the execution environment for user applications and enterprise applications are not the same (e.g., as shown in FIGS. 8 through 12).

In some embodiments, device 110 accesses various network-based voice services, such as consumer voice services 167 and/or enterprise sponsored/paid-for consumer voice services usage, via voice network 165. As shown, voice network 165 is in communication with carrier access network 150 via carrier gateway/home agent (HA) 152. In some embodiments, device 110 accesses various Internet based services, such as consumer Internet services 162 and/or enterprise sponsored/paid-for consumer Internet services usage, via Internet 160.

As also shown in FIG. 1, device 110 is in wireless communication (e.g., 2G/3G/4G access) with carrier access network 150. The carrier provides a carrier usage accounting server 154 (e.g., a carrier billing server) in communication with carrier access network 150. Carrier network access 150 is shown in communication with both Internet 160 and enterprise network 170 via Internet 160. Enterprise network 170 is shown in communication with Internet 160 as via enterprise firewall and secure access gateway 171 for protecting enterprise network 170 from unauthorized access. In some embodiments, to access enterprise network 170 through enterprise firewall and secure access gateway 171, device 110 includes a secure data application or a virtual private network application/function to facilitate secure authorization with enterprise firewall and secure access gateway 171 and to also protect the communication (e.g., encrypt such data communications). As also shown, behind enterprise firewall and secure access gateway 171, enterprise network 170 provides communication with secure enterprise mobile services gateway/server 172 in communication with enterprise network 170. As shown, secure enterprise mobile services gateway server 172 includes various enterprise applications/functions, including as shown, mobile email 173, mobile synchronization 174, mobile contacts 175, mobile calendar 176, mobile communications 177, and mobile intranet 178. In some embodiments, secure enterprise mobile services gateway server 172 provides mobile device mobile access to various enterprise network intranet services via enterprise intranet servers 180. In some embodiments, the enterprise mobile services include email, contacts, calendar, enterprise communications, mobile device synchronization services, intranet internal web sites, internal

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enterprise applications, enterprise file systems, and/or other enterprise networking services. In some embodiments, secure enterprise mobile services gateway server 172 provides optimized mobile application formatting of the enterprise information or synchronization services to synchronize the enterprise database for the above services in an efficient and/or timely manner.

In some embodiments, carrier usage accounting server 154 (e.g., the carrier billing server) communicates (e.g., using secure communication techniques) with service usage reconciliation server function 158 to obtain reconciled service charging reports (e.g., reconciled billing reports) and/or enterprise service usage charging credit reports. In some embodiments, the reconciled service charging reports (e.g., reconciled billing reports) and/or enterprise service usage charging credit reports are processed by carrier usage accounting server 154 and reported as user usage record(s) 155 and/or enterprise usage record(s) 156. For example, mediating such charging and credit reports can be based on various factors as described herein (e.g., by application, time of day/day of week, and/or other factors). For example, the service usage charges that occur due to communication with the servers or services that are part of enterprise network 170, including secure enterprise mobile services gateway server 172 and intranet servers 180, can be counted as an enterprise service usage credit.

In some embodiments, enterprise service design center 194 issues device provisioning instructions for the device credential list from the enterprise services device group, and for each of the credentials, a service control policy is set on enterprise firewall/secure gateway 171 to allow properly authorized devices to reach the desired destinations listed on the enterprise service activity policy set. The provisioning of enterprise firewall/secure gateway 171 with the enterprise service device group credentials and the enterprise service policy set is illustrated in FIG. 1 by the "C" input designator.

In some embodiments, enterprise service design center UI 196 and enterprise service design center 194 are provided as shown in FIG. 1. In some embodiments, enterprise service design center UI 196 and enterprise service design center 194 provide dedicated enterprise control of the network policy provisioning for configuring the service charging, accounting or billing allocation policies for differentiating between enterprise device service usage activities and consumer device service usage activities. Furthermore, in some embodiments, the portion of the enterprise network policy provisioning information that is needed to provision the carrier network elements to implement various techniques for allocating device service usage between enterprise and consumer activities is communicated between enterprise service design center 194 and carrier service design center 190.

A carrier provisioning system is typically not capable of providing direct access to an enterprise network administrator (e.g., carrier or enterprise personnel) for the purpose of provisioning such service charging capabilities. For example, such direct access is often not provided due to concerns related to the risk to the entire network that exists if network provisioning controls are made available to many different administrators to program charging allocation policies for many enterprises. However, as described herein, by isolating the required carrier network provisioning information to a secure service design center UI and policy configuration that only influences a small portion of the carrier network policy provisioning available to the carrier service design center and UI, the risk of causing such problems with the carrier network configuration is significantly reduced.

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Additionally, the process of performing the carrier side of the necessary provisioning is simplified for an administrator or in some cases can be automated.

The service design centers (e.g., carrier service design center **190** and enterprise service design center **194**) are shown in FIG. 1 and various other figures as separate network elements in order to more clearly define and discuss the functions of the service design centers. In some embodiments, enterprise service design center **194** is implemented in various other network elements (e.g., in enterprise network management apparatus, such as management functions of secure enterprise mobile services gateway server **172** or other enterprise network management apparatus). In some embodiments, enterprise service design center **194** is implemented as a securely partitioned and managed device group interface to a subset of the provisioning capabilities of carrier network service design center **190**. In some embodiments, enterprise service design center **194** is implemented as a securely partitioned and managed device group interface to a subset of the provisioning capabilities of a cloud-based secure enterprise mobile services network that is run by a centralized enterprise services provider such as an ASP or MVNO. As would be appreciated by one of ordinary skill in the art in view of the various embodiments described herein, enterprise service design center **194** can be implemented using various network and software/hardware architectures while providing for secure and controlled access as described herein.

In some embodiments, the enterprise service design center administrator creates or imports the enterprise service device group credentials and the enterprise service policy set using enterprise service design center UI **196**. In some embodiments, the information included in the enterprise service device group credentials and the enterprise service policy set is also communicated from enterprise service design center **194** to carrier service design center **190** via the "C" connection designator as shown. For each of the device credentials listed in the enterprise services device group, carrier service design center **190** determines the information it needs to properly provision carrier gateway/home agent **152** with the proper access policy allowances and service usage charging policies to provide enterprise service access and usage credit for communications from device **110** to the enterprise network destination addresses specified in the enterprise service policy set. Programming of this provisioning information to carrier gateway/home agent **152** is indicated by the "A" information connector from carrier service design center **190** to carrier gateway/home agent **152**. In some embodiments, this provisioning (e.g., programming) information sent via provisioning communication link "A" to carrier gateway/home agent **152** includes information to facilitate programming the enterprise device group credentials to: (i) receive the desired access service policy permissions, and (ii) implement the desired service usage accounting/charging policy settings. From the enterprise device group credentials list and the enterprise service activity policy set information provided in "C," carrier service design center **190** determines the information needed to properly provision the service usage reconciliation server function **158**. Programming of this provisioning information to service usage reconciliation server function **158** is indicated by the "B" information connector from carrier service design center **190** to service usage reconciliation server function **158**. In some embodiments, service usage reconciliation function **158** is part of the carrier network, and service usage reconciliation function **158** implements the charging reconciliation rules to determine how much of the

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recorded device **110** service usage to place on the user's usage record or service bill (e.g., consumer service usage cost allocation) and how much to place on the enterprise's usage record or service bill (e.g., enterprise service usage cost allocation).

An enterprise may wish to allow consumer services on an end-user device that also allows an employee to access enterprise services over the access network. In some such embodiments, service design center **190** specifies one or more service plans from which the device user can select, and these service plan selection options are configured into a configuration interface on a device software application (e.g., user data app **111**, user voice app **112** or service processor framework program **139** (shown, e.g., in FIG. 16)) that allows users to select from one or more service plans, for example, one or more plans with both consumer and enterprise allocations, and/or an enterprise-only service plan. In some embodiments, the configuration interface is made available directly on the device via a device client that provides a service plan selection user interface that displays one or more service plan options configured in service design center **190** or enterprise service design center **194**. In some embodiments, the configuration interface is presented directly on the device user interface (UI) when the user attempts an access service usage activity that requires a service plan to be activated or purchased. In some embodiments, the configuration interface presented to the device UI accepts a user response and assists in sending the user response to a carrier network element responsible for provisioning a new user service plan that in turn activates the service plan chosen by the user, possibly after confirming service payment credit for the user or enterprise entity. In some embodiments, the carrier network element responsible for provisioning a new user service plan is carrier usage accounting server **154**. In some embodiments, the carrier network element responsible for provisioning a new user service plan is consumer Internet services elements **162**. In some embodiments, the carrier network element responsible for provisioning a new user service plan is a carrier gateway/home agent **152**. In some embodiments, the carrier network element responsible for provisioning a new user service plan is a billing system or service plan provisioning system. In some embodiments, the configuration interface is made available to the user in the form of a web site that provides a service plan selection user interface that displays one or more service plan options configured in service design center **190** or enterprise service design center **194**.

In some embodiments, the initial configuration of device **110** includes one or more enterprise access service plans that allow the user to access certain applications or network destinations associated with enterprise access services, and the user can choose from one or more additional consumer-oriented service plans offered directly on the device UI by a device software application (e.g., user data app **111**, user voice app **112**, or service processor framework program **139**) in communication with a carrier network element responsible for provisioning a new user service plan that in turn activates the service plan chosen by the user, possibly after confirming service payment credit for the user or enterprise entity. In some embodiments, these access service plan options are configured using service design center **190**. In some embodiments, these access service plan options are configured using enterprise service design center **194**.

In some embodiments in which a user has selected a consumer-oriented service plan in addition to an enterprise service plan, service usage reconciliation function **158** distinguishes between data usage within the enterprise service

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plan and data usage within the consumer-oriented service plan. In some embodiments, the enterprise does not pay for, backhaul, process, or police data usage associated with the consumer-oriented plan. In some embodiments, service usage reconciliation function **158** determines how much data usage by device **110** is enterprise data usage, and how much data usage by device **110** is consumer data usage. In some embodiments, service usage reconciliation function **158** allocates data usage associated with applications and/or services specified by the enterprise service plan to the enterprise, and data usage associated with applications and/or services specified by the consumer-oriented data plan to the consumer.

The various embodiments described herein with respect to FIG. **1** support a variety of techniques for allocating service usage accounting or billing between enterprise services and consumer services. For example, service usage reconciliation function **158** can report measured total usage, measured consumer usage, and/or measured enterprise usage to carrier usage accounting server **154**. In some embodiments, the reconciliation service usage function (e.g., provided by service usage reconciliation function **158** and/or another element/function) implements the business rules that determine how much of the service usage to charge the user (e.g., a consumer service usage allocation) and how much of the service usage to charge the enterprise (e.g., an enterprise service usage allocation). In some embodiments, the service usage reconciliation service usage function records total device service usage, records total enterprise service activity service usage, and then subtracts the enterprise service usage from the total device service usage to determine a consumer service usage (e.g., a consumer service usage allocation). In some embodiments, service usage reconciliation function **158** passes on the enterprise service usage as a credit to the consumer account. In some embodiments, this credit is accounted for by the carrier billing the user at a reduced amount according to the credit and billing the enterprise for an increased amount according to the credit. In some embodiments, the credit is accounted for by communicating the credit to the enterprise so the enterprise can reimburse the consumer (e.g., generating an expense reimbursement for the credit to the consumer as an employee or contractor of the enterprise, directly paying the enterprise allocation of the carrier bill for the consumer, and/or various other approaches as described herein). In some embodiments, the credit is reported to the enterprise so that the enterprise can seek payment for the non-enterprise service usage (e.g., consumer service usage allocation) from the consumer (e.g., who can be an employee or contractor of the enterprise).

As another example, an enterprise allocation can also include providing an allowance for a certain level of monthly usage of data and/or voice. In some embodiments, carrier usage accounting server **154** generates a bill for the associated consumer account (e.g., associated with device **110**, such as based on the device/user credentials) that reflects the cost of the service usage allocated to consumer service usage and a credit for the cost of service usage allocated to enterprise service usage (e.g., to offset the cost of the enterprise service usage, which can be billed to the enterprise account associated with the enterprise service usage for the device **110**). As described herein, based on an allocation of enterprise and consumer service usage, various techniques for billing/charging and generating credits/reporting (e.g., the enterprise can generate the user/employee monthly expense reimbursements to compensate the user/employee for the determined cost of the enterprise service usage and/or other approaches as described herein) can be

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provided using the network architecture **100** and/or other network architectures, as described herein.

In some embodiments, an enterprise manager manages service usage by specifying an access network service usage limit for a service usage activity (such as data service, voice service, text service, a roaming service, or a more detailed classification of data service such as one or more websites or one or more device applications), and, when that usage limit is reached for a device that is managed by the enterprise manager, a service usage notification message is generated. In some embodiments, the service usage notification message is configured through enterprise service design center UI **196**. In some embodiments, the service usage notification message is delivered to device **110**. In some embodiments, the service usage notification message is presented to the user via a user interface of device **110**.

In some embodiments, the service usage notification message provides information about data usage or the status of device **100**. In some embodiments, the service usage notification message is triggered by an event, e.g., detection that device **110** reaches a data usage ceiling, determination that device **110** is roaming, etc. In some embodiments, the service usage notification message provides real-time or near-real-time information about data usage. In some embodiments, the service usage notification message provides information about remaining data usage availability or entitlement. In some embodiments, the service usage notification message comprises a detailed report of enterprise usage by user, user group, device, device group, or location.

In some embodiments, secure enterprise mobile services gateway server **172** is a dedicated enterprise application server for a particular enterprise (e.g., company, government organization, school/university, or another entity). In some embodiments, secure enterprise mobile services gateway server **172** is a carrier or a third party service provider (e.g., a carrier for wireless network services, such as AT&T, Sprint, T-Mobile, and/or various other wireless network service providers/carriers or third party service providers) controlled/managed application server that performs the application server functions for various different enterprises (e.g., as a service/outsourced IT services model). In some embodiments, device **110** is partitioned (e.g., associated with a particular enterprise/MVNO partition and associated enterprise account) based on device credentials and/or VPN to determine a service plan for managing (e.g., to determine how to allocate enterprise/consumer service usage for) device **110**. In some embodiments, based on the partition determination of device **110**, and the associated service plan for managing device **110**, appropriate service usage monitoring and classification can be determined for providing an enterprise and consumer allocation for service usage activities of device **110** based on the associated service plan(s).

For example, by programming the business rules in service usage reconciliation function **158** that determine the service usage accounting allocation between enterprise services and consumer services, many approaches can be provided for creating a service that provides an enterprise service to a device when the device user has selected a consumer service plan or elected to pay for a consumer service plan. As an example, if the device user has chosen a service plan, the enterprise service usage accounted for in enterprise usage record **156** can be billed to the enterprise rather than the consumer. As another example, if the device user has chosen a service plan, the consumer service usage accounted for in user usage record **155** can be billed to the device user rather than the enterprise. As yet another example, if the device user has selected a service plan, the

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enterprise service usage can be communicated to the enterprise (e.g., and/or the device user), and the enterprise can issue a reimbursement to the device user for the enterprise portion of the user's bill, or pay the carrier directly for a portion of the user's bill, thus reducing the amount the user must pay. In some embodiments, the business rules in service usage reconciliation function **158** are programmed to provide the device user with a certain amount of service usage that may or may not be directly related to enterprise services.

For example, the user can be allocated a certain amount of general purpose browsing that includes network destinations that are not specified in the enterprise service activity policy set. In some embodiments, there is a cap to such general purpose browsing, and carrier service design center **190** can provision the network and/or the device to alert the user regarding how much of the enterprise sponsored browsing remains or when the enterprise sponsored internet browsing cap is reached or exceeded. In some embodiments, the business rules in service usage reconciliation function **158** are programmed to deduct the service usage associated with the enterprise sponsored general purpose browsing, up to the specified cap, from the user's bill. In this way, the user can be allocated an allowance for services that either the enterprise sponsors to account for enterprise related service usage that may not be included in the enterprise service activity policy set or that the enterprise simply desires to sponsor to reduce the device user's consumer service plan billing.

In a similar manner, services other than browsing that are not necessarily associated with enterprise service usage can also be sponsored by the enterprise by properly provisioning the business rules in service usage reconciliation function **158**. For example, a catch-all enterprise sponsored allowance (e.g., or cap) for "bulk" internet usage can be provided. The fact that the user is provided with such an allowance may be pointed out to the user if the user disputes how much of his or her device service usage cost should be covered by the enterprise and how much the user should cover personally. Another example is to provide a certain amount of voice minutes to any phone number or to phone numbers not in the enterprise service activity policy set.

In some embodiments, the business rules in service usage reconciliation function **158** are provisioned so that the enterprise specifically does not allow, sponsor, or pay for certain device service usage activities. In some embodiments, these service usage activities can include access to network destinations, applications, or services that pose security risks to enterprise data stored on device **110** or pose security risks to enterprise network **170**. In some embodiments, these activities include access to network destinations, applications, or services that the enterprise does not wish to sponsor or that are potentially associated with user activity that violates enterprise policy or laws. For example, the business rules may be configured to allow only transmission of business data on approved networks, e.g., excluding free or unknown WiFi hotspots, or only when device **110** is connected to the network via a VPN. In some embodiments, such service usage activities that violate enterprise security policies or other service usage policies are blocked by the business rules programmed into the network or the device as specified in the enterprise service activity policy set.

By programming the business rules in service usage reconciliation function **158** that determine the service usage accounting allocation between enterprise services and consumer services, many approaches can be provided for cre-

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ating a service that provides an enterprise service to a device when the device user has not selected a consumer service plan or elected to pay for a consumer service plan. For example, if the device user has not chosen to select or pay for a consumer service plan, carrier gateway/home agent **152** can be programmed to allow service usage for the enterprise service policy set but deny all other access until the user chooses a consumer service plan. In some embodiments, when/if the consumer chooses a consumer service plan then access would be expanded beyond just the enterprise services, because when the service plan activation occurs, consumer service policy set in carrier gateway/home agent **152** will be updated to allow service (e.g., as the carrier administrator user of carrier service design center **190** programs a different set of consumer service access policies for each consumer service plan that can be chosen). In some embodiments, the user is allocated a certain amount of general purpose data access or voice minutes as described above even though the user does not have a consumer data plan. Another example is to provide the user with a certain monetary allowance that is sponsored by the enterprise rather than a service usage amount.

Although enterprise service design center **194** is shown provisioning mobile server usage counter **179** (e.g., shown in FIG. 5) and enterprise firewall/secure gateway **171**, it should be understood that not all device provisioning connections as shown from secure enterprise mobile services gateway/server **172** to device **110** are shown for device functions including secure mobile services application access, communication link provisioning (e.g., cryptographic encryption keys, VPN settings, and various other security/communication provisioning), security programs, service control programs, and program settings for enterprise service applications, such as email, calendar, contacts, mobile synchronization services, and traffic control. As shown, the labeled provisioning connections are provided as exemplary embodiments to assist in identifying the network elements that are provisioned for network access control and network service usage charging reporting. Those of ordinary skill in the art will appreciate that these additional device provisioning functions are not necessarily specifically called out with provisioning connection labels in each figure, and it will be apparent to one of ordinary skill in the art which of these device provisioning functions and connections are needed from enterprise service design center **194** and device **110**. It will also be apparent to one of ordinary skill in the art in view of the various embodiments described herein that the various device provisioning connections and device element programming configurations needed to provision these device functions can be managed by secure enterprise mobile services gateway/server **172** via a device management communications link. It will also be apparent to one of ordinary skill in the art that, in some embodiments, the flow of policy provisioning information for the various device elements that participate in establishing service usage monitoring and reporting policies or service access control policies starts in enterprise service design center **194** and flows through secure enterprise mobile services gateway/server **172** over a device management link, and through the device management link on device **110** to the device **110** functional elements that need to be provisioned. In various embodiments described herein, the device elements that are provisioned in some embodiments to set up enterprise services, service usage monitoring and reporting policies, or service usage access control policies include one or more of enterprise data application **124**, enterprise voice application **126**, secure mobile enterprise application environment **120**

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(shown, e.g., in FIG. 8), secure network interface **128** (shown, e.g., in FIG. 8), secure enterprise mobile services application **125** (shown, e.g., in FIG. 13), virtual machine #2 secure enterprise application environment **118** (shown, e.g., in FIG. 14), enterprise application secured hardware execution partition **106** (shown, e.g., in FIG. 15), device service usage monitor **119** (shown, e.g., in FIG. 17), service processor framework program **139** (shown, e.g., in FIG. 16), and/or service processor kernel program **138** (shown, e.g., in FIG. 16).

In some embodiments, service usage reconciliation function **158**, or secure enterprise mobile services gateway/server **172**, or another similar network function, is programmed to review traffic usage patterns of mobile device **110** for the purpose of determining if the device may have fallen into unauthorized hands or if the device secure enterprise communications and data management software may have been hacked or tampered with in a way that endangers enterprise security or causes the enterprise to be billed for usage that is not enterprise usage. For example, service usage reconciliation function **158** (e.g., or secure enterprise mobile services gateway/server **172**) can be programmed to monitor “bulk” enterprise service usage for the enterprise device group and trigger a fraud detection alert for a device that exhibits enterprise usage that is higher than a pre-determined “normal” limit. As another example, service usage reconciliation function **158** can be programmed to monitor “bulk” enterprise service usage for the enterprise device group and trigger a fraud detection alert for a device that exhibits enterprise usage access patterns that are determined to be outside of “normal” limits. Examples of usage patterns can include usage as a function of time of day, duration of usage, usage above a certain limit for a subset of service usage activities, and/or usage above a certain limit for all service usage activities.

In some embodiments, enterprise service design center **194** is configured to receive or accept a specification for an access network service usage limit (e.g., a service amount in minutes, bytes, or cost) for a service usage activity (such as a data service, a voice service, a text service, a roaming service, or a more detailed classification of a data service, such as one or more websites or one or more device applications), and the service usage limit is applied to one or more devices **110** or device groups (or users or user groups) managed by enterprise service design center **194**. In some embodiments, enterprise service design center **194** is further configured to receive service usage records for device **110**, which is managed by enterprise service design center **194**, from a network element configured to monitor and report device **110** service usage (e.g., carrier usage accounting server **154**, enterprise firewall/security gateway **171**, or another network element), and when the usage limit is reached, to generate a service usage notification message. In some embodiments, enterprise service design center **194** is configured to deliver the service usage notification message to enterprise service design center UI **196**. In some embodiments, enterprise service design center **194** is configured to deliver the service usage notification message to a software application of device **110** (e.g., service processor framework program **139** or user data app **111**) for presentation to the device user through a user interface of device **110**.

In some embodiments, enterprise service design center **194** is configured to receive or accept a specification for an access network service notification event consisting of a network access pattern achieved or attempted by device **110** that belongs to a device group (or user group) managed by enterprise service design center **194**, wherein the network

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access pattern is access attempted or achieved by one or more pre-defined device applications, or access attempted or achieved by device **110** to one or more network destinations, websites or network servers. In some embodiments, enterprise service design center **194** is further configured to receive service usage records for device **110**, which is managed by enterprise service design center **194**, from a network element configured to monitor and report device **110** service usage (e.g., carrier usage accounting server **154**, enterprise firewall/security gateway **171**, or another network element), and when the service usage indicates that the network access pattern has occurred, enterprise service design center **194** is further configured to send a notification message to enterprise service design center UI **196**.

Carrier Managed Billing Allocation with Service Usage Monitoring in Carrier Network and Enterprise Firewall/Gateway

FIG. 2 illustrates a functional diagram of another network architecture **101** for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. Network architecture **101** of FIG. 2 is similar to network architecture **100** of FIG. 1, except that in network architecture **101** of FIG. 2, service usage reconciliation function **158** receives service usage information from enterprise firewall/secure gateway **171** in addition to carrier gateway/home agent **152**. This allows for various techniques that augment the capabilities of carrier gateway/home agent **152**. For example, in networks in which it is impractical or infeasible for carrier gateway/home agent **152** to keep track of the service usage accounting allocation between the enterprise service policy set and consumer services for the devices in the device group, service usage reconciliation function **158** can receive total device service usage from carrier gateway/home agent **152**, and receive the enterprise service usage from enterprise firewall/secure gateway **171**. With this information, service usage reconciliation service usage function **158** can perform the allocation between enterprise service usage and consumer service usage without any detailed service usage reports from carrier gateway/home agent **152**.

There are several reasons that the carrier network may not support numerous enterprise service customers with an enterprise/consumer allocation architecture that requires carrier gateway/home agent **152** to perform the necessary traffic classification or service usage classification as in the FIG. 1 embodiment. For example, these reasons can include: (i) carrier gateway/home agent **152** does not have the detailed service usage classification capability (e.g., deep packet inspection function(s)) required to allocate service usage between the enterprise service policy set and consumer services for the devices in the device group, (ii) carrier gateway/home agent **152** is capable of performing the service monitoring required but can only do it for a limited number of devices (e.g., scaling issues), and/or (iii) there are too many device groups being managed by enterprise partners of the carrier creating a situation where the number of specialized profiles that must be supported by carrier gateway/home agent **152** is larger than can be accommodated by the profile management capacity of the gateway system (e.g., scaling issues). As would now be apparent to those of ordinary skill in the art in view of the embodiments described herein, there are other reasons that can make it advantageous to provide the enterprise service usage from the enterprise network.

In some embodiments, provisioning with the service design centers and UIs for the embodiment shown in FIG. 2 is similar to that of FIG. 1. In some embodiments, the billing

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allocation capabilities of the two embodiments are similar if carrier gateway/home agent **152** is fully capable of differentiating service usage between the enterprise service policy set and the consumer services, but if not, then as discussed above, the billing allocation capabilities of the FIG. 2 embodiment can be preferable in such environments.

Because the enterprise service usage is monitored by the enterprise network elements in the embodiments depicted in FIG. 2, various service accounting or billing policies are available to the enterprise or carrier. For example, the amount of service usage resulting from enterprise services that occur during roaming conditions can be accounted for even when the carrier network does not receive detailed classification of service usage from roaming network partners. The business rules programmed into service usage reconciliation function **158** that are determined by the enterprise service activity policy set can break-out enterprise-service-related roaming charges separately from consumer-service-related roaming charges so that the enterprise-service-related roaming charges are sponsored or paid by the enterprise and consumer roaming service usage activities are not subsidized or are only partially subsidized. In addition, in some embodiments, secure enterprise mobile services gateway/server **172** includes the capability to determine if device **110** is roaming so that the access control policies specified in the enterprise service activity policy set can include modification or denial of access to enterprise network **170** services allowed by enterprise firewall/secure gateway **171** or secure enterprise mobile services gateway/server **172** during roaming conditions even though the access is not controlled by the carrier home network.

In some embodiments, an active network detection function is included on the device to assist the network policy enforcement elements to determine the type of network the device is connected to or to determine if the device is on a home or roaming network, as described herein. For example, the service usage policy allowances provided by the enterprise service activity policy set can be programmed so that the allowances change depending on the availability of a particular network or set of networks, the time of day, the congestion state of a network, or the current cost of service on the network. For example, if the carrier home network is not available and only a roaming network is available, the allowance may be decreased or removed. As another example, if a certain network type is not available but another network type is (e.g., 2G is available instead of 3G or 3G is available instead of 4G), then the allocation can be reduced. As yet another example, if a variable charging policy is in place with the carrier for access when the network is busy or during certain times of day, then the enterprise sponsored allowance can be reduced during times of higher charging.

Enterprise Managed Billing Allocation with Service Usage Monitoring in Carrier Network and Enterprise Firewall/Gateway

FIG. 3 illustrates a functional diagram of another network architecture **102** for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. Network architecture **102** of FIG. 3 is similar to network architecture **101** of FIG. 2, except that in network architecture **102** of FIG. 3, service usage reconciliation function **158** receives overall device service usage information from carrier usage accounting server **154** and also receives enterprise device service usage information from enterprise firewall/secure gateway **171**. In some embodiments, there is no interaction between the provisioning of the carrier network

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and the provisioning of the enterprise network, and it is assumed that service usage reconciliation function **158** and enterprise usage accounting server **159** are both under the control of the enterprise administrator. This approach allows for various techniques that provide for enterprise allocation of consumer service usage and enterprise service usage without the need to interface to the carrier network other than to get the overall usage summary. For example, service usage reconciliation function **158** can receive total or "bulk" usage from carrier usage accounting server **154**, receive enterprise service usage from enterprise firewall/secure gateway **171**, and determine the amount of consumer service usage, enterprise service usage, and/or an enterprise service usage credit.

In some embodiments, provisioning with the service design centers and UIs for the embodiment shown in FIG. 3 is similar to that of FIG. 1 except that no provisioning of enterprise service parameters is required in the carrier network. The billing allocation capabilities are also similar if carrier gateway/home agent **152** is fully capable of differentiating service usage between the enterprise service policy set and the consumer services, but if not, then as discussed above, the billing allocation capabilities of the FIG. 3 embodiment can be preferable in such environments. For example, using network architecture **102**, the enterprise can deal directly with its employees without the need to bring the carrier into the consumer-versus-enterprise allocation process. As an example, the enterprise could have a policy in which consumers purchase their own mobile device services and then get credit for enterprise mobile device services at the end of each billing period. This credit can be provided back to the employee in the form of an expense reimbursement or an increase in their next paycheck.

Enterprise Usage Credit with Service Usage Monitoring in Enterprise Firewall/Gateway

FIG. 4 illustrates a functional diagram of another network architecture **103** for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. Network architecture **103** of FIG. 4 is similar to network architecture **102** of FIG. 3, except that in network architecture **103** of FIG. 4, service usage reconciliation server function **158** receives no overall device service usage information from the carrier network. As shown in FIG. 4, the source of service usage information is enterprise network **170** (e.g., via the enterprise firewall/secure gateway **171**). In some embodiments, there is no interaction between the provisioning of the carrier network and the provisioning of the enterprise network, and it is assumed that service usage reconciliation function **158** and enterprise usage accounting server **159** could both be under the control of the enterprise administrator. For example, network architecture **103** of FIG. 4 can be less dependent on the carrier than network architecture **102** of FIG. 3 in that no billing information feed is provided. Using various techniques described herein, an enterprise service usage credit can be determined, and the determined enterprise service usage credit can be reimbursed to the device user.

Carrier Managed Billing Allocation with Service Usage Monitoring in Carrier Gateway/Home Agent and Enterprise Mobile Services Gateway Server

FIG. 5 illustrates a functional diagram of another network architecture **200** for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. Network architecture **200** of FIG. 5 is similar to network architecture **101** of FIG. 2, except that in network architec-

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ture 200 of FIG. 5, secure enterprise mobile services gateway/server 172 includes mobile server usage monitor 179, and the enterprise service usage reports from this function are sent to service usage reconciliation function 158 instead of usage reports being sent from enterprise firewall/secure gateway 171. In some embodiments, various specialized needs of monitoring, recording, and reporting enterprise service usage are confined to the special-purpose secure enterprise mobile services gateway/server 172 rather than requiring the often more general-purpose enterprise firewall/secure gateway 171 to perform these functions. Enterprise Managed Billing Allocation with Service Usage Monitoring in Carrier Network and Enterprise Mobile Services Gateway Server

FIG. 6 illustrates a functional diagram of another network architecture 201 for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. Network architecture 201 of FIG. 6 is similar to network architecture 102 of FIG. 3, except that in network architecture 201 of FIG. 6, secure enterprise mobile services gateway/server 172 includes mobile server usage monitor 179, and the enterprise service usage reports from this function are sent to service usage reconciliation function 158 instead of usage reports being sent from enterprise firewall/secure gateway 171. For example, this approach allows for the specialized needs of monitoring, recording, and reporting enterprise service usage to be performed by the special-purpose secure enterprise mobile services gateway/server 172 rather than requiring the often more general-purpose enterprise firewall/secure gateway 171 to perform such functions.

Enterprise Usage Credit with Service Usage Monitoring in Enterprise Mobile Services Gateway Server

FIG. 7 illustrates a functional diagram of another network architecture 202 for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. Network architecture 202 of FIG. 7 is similar to network architecture 103 of FIG. 4, except that in network architecture 202 of FIG. 7, secure enterprise mobile services gateway/server 172 includes mobile server usage counter 179, and the enterprise service usage reports from this function are sent to service usage reconciliation function 158 instead of usage reports being sent from enterprise firewall/secure gateway 171. For example, this approach allows for the specialized needs of monitoring, recording and reporting enterprise service usage to be performed by the special-purpose secure enterprise mobile services gateway/server 172 rather than requiring the often more general-purpose enterprise firewall/secure gateway 171 to perform such functions.

Carrier Managed Billing Allocation with Device Mobile Enterprise Services Application Environment and Service Usage Monitoring in Carrier Network

FIG. 8 illustrates a functional diagram of another network architecture 300 for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. As shown, secure mobile enterprise application environment 120 and secure network interface 128 within secure mobile enterprise application environment 120 are included in device 110. Also, server secure network interface 127 is included in secure enterprise mobile services gateway/server 172. In some embodiments, secure mobile enterprise application environment 120 protects sensitive enterprise information that is stored on device 110 (e.g., email text and

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downloads, calendar information, contacts, intranet data, or any other enterprise data) and provides a secure communication channel function to allow for authentication with server secure network interface 127 on secure enterprise mobile services gateway/server 172. As also shown, a user services application environment in device 110 includes various user applications, such as user data application 111 and user voice application 112.

In some embodiments, provisioning of the various network architecture elements to facilitate the allocation between enterprise service usage accounting or billing and consumer service usage accounting or billing is established as follows. The device portion of secure network interface 128 and the enterprise server portion of server secure network interface 127 are provisioned with connection "E." In some embodiments, this provisioning operation with the connection labeled "E" includes programming information for secure network interface 128 to direct enterprise network 170 access traffic associated with application functions running in secure mobile enterprise application environment 120 to enterprise network 170 destinations that are to be sponsored (and, in some embodiments, possibly intermediate network routes) according to the enterprise services policy set, including, for example, the addresses (e.g., IP, IP/port or other higher layer address identifiers) of secure enterprise mobile services gateway/server 172 or enterprise intranet servers 180. In some embodiments, the provisioning operation designated with the connection label "E" also establishes the parameters required for the secure communication of information between secure network interface 128 and server secure network interface 127. In some embodiments, this provisioning step sets up the policies for the authentication process, data encryption, and cryptographic key exchange processes take place to establish secure communication between secure mobile enterprise application environment 120 and secure enterprise services gateway/server 172.

In some embodiments, the enterprise network destinations that are to be sponsored according to the enterprise services policy set identified by provisioning connection "E" are also communicated to carrier service design center 190. For example, this allows carrier service design center 190 to determine and transmit the proper provisioning information to establish the access control policies or service usage accounting policies for these aspects of the enterprise services policy set. Carrier service design center provisioning connections "A" communicate the provisioning information (programming) to carrier gateway/home agent 152. Carrier service design center provisioning connections "B" communicate the provisioning information (programming) to service usage reconciliation function 158.

In some embodiments, the provisioning operation associated with the provisioning connection label "C" provisions enterprise firewall/secure gateway 171 to admit devices 110 with device credentials or application credentials that belong to the desired enterprise services device group associated with the enterprise service policy set. In some embodiments, the provisioning information labeled as "C" includes enterprise network 170 destinations that are to be sponsored (and, in some embodiments, possibly intermediate network routes) according to the enterprise services policy set. In some embodiments, the provisioning information labeled as "C" includes only the network destinations for secure enterprise mobile services gateway/server 172, and devices 110 are not allowed access to other parts of enterprise network 170.

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In some embodiments, network architecture **300** for providing enterprise and consumer billing allocation for wireless communication device service usage activities includes executing an enterprise application as a secure enterprise data application **124** in secure mobile enterprise application environment **120** of device **110** in which the secure applications are in network communication (e.g., secure network communication, such as via a virtual private network (VPN) or other secure network communication techniques) with secure enterprise mobile services gateway/server **172** (e.g., executing an enterprise server side of the enterprise authorized/sponsored applications, such as an enterprise email server, an enterprise calendar server, an enterprise contacts server, and/or an enterprise network access server) of the enterprise. In some embodiments, the secure enterprise mobile services gateway/server **172** performs application monitoring that includes counting application service usage (e.g., bytes used in communicating with the device's execution of secure enterprise application **124**). In some embodiments, secure enterprise mobile services gateway/server **172** performs application monitoring that further includes classifying application service usage (e.g., classifying secure enterprise application **124** by application/service usage activity such as based on application name or using signed code/hash techniques, by time of day/day of week, enterprise server, destinations, enterprise intranet, and/or other factors).

Carrier Managed Billing Allocation with Device Mobile Enterprise Services Application Environment and Mobile Services Gateway Server with Service Usage Monitoring in Carrier Network

FIG. **9** illustrates a functional diagram of another network architecture **301** for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. Network architecture **301** of FIG. **9** is similar to network architecture **300** of FIG. **8**, except that in network architecture **301** of FIG. **9**, secure enterprise mobile services gateway/server **172** is located between the Internet **160** and enterprise network **170**. For example, this approach allows for server secure network interface **127** of secure enterprise mobile services gateway/server **172** to restrict access to enterprise network **170** and enterprise intranet servers **180** based on device authentication and/or various other security techniques (e.g., secure access, authentication, and/or communication techniques), as would be apparent to one of ordinary skill in the art in view of the various embodiments described herein.

Carrier Managed Billing Allocation with Device Mobile Enterprise Services Application Environment and Mobile Services Gateway Server with Service Usage Monitoring in Carrier Network and Mobile Services Gateway Server

FIG. **10** illustrates a functional diagram of another network architecture **302** for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. Network architecture **302** of FIG. **10** is similar to network architecture **301** of FIG. **9**, except that in network architecture **302** of FIG. **10**, secure enterprise mobile services gateway/server **172** includes mobile service usage monitor **179** that reports enterprise service usage to the service usage reconciliation function **158**. In some embodiments, various specialized needs of monitoring, recording, and reporting enterprise service usage are confined to the special-purpose enterprise mobile services gateway/server **172** rather than requiring the often more general-purpose enterprise firewall/

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secure gateway **171** and/or other network elements/functions to perform such functions.

Enterprise Managed Billing Allocation with Device Mobile Enterprise Services Application Environment and Mobile Services Gateway Server with Service Usage Monitoring in Mobile Services Gateway Server

FIG. **11** illustrates a functional diagram of network architecture **303** for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. Network architecture **303** of FIG. **11** is similar to network architecture **302** of FIG. **10**, except that network architecture **303** of FIG. **11** includes another carrier usage accounting server **154B** that reports service usage to service usage reconciliation function **158**. In some embodiments, carrier usage accounting server **154B** receives overall or bulk service usage data from carrier gateway/home agent **152** and forwards such information to service usage reconciliation function **158**. Service usage reconciliation function **158** reconciles the overall or bulk service usage received from carrier accounting server **154B** and the enterprise service usage received from mobile server usage monitor **179** and provides such reconciled service usage information to carrier usage accounting server **154A**.

Enterprise Usage Credit with Device Mobile Enterprise Services Application Environment and Mobile Services Gateway Server with Service Usage Monitoring in Mobile Services Gateway Server

FIG. **12** illustrates a functional diagram of network architecture **304** for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. Network architecture **304** of FIG. **12** is similar to network architecture **303** of FIG. **11**, except that in network architecture **304** of FIG. **12**, the only service usage reported to service usage reconciliation function **158** is the enterprise service usage received from mobile server usage monitor **179**. In some embodiments, service usage reconciliation function **158** reconciles the enterprise service usage received from mobile server usage monitor **179** and provides such reconciled service usage information to carrier usage accounting server **154**, which generates enterprise service usage record(s) **156**. Device Configurations without Service Usage Monitoring and Reporting

FIG. **13** illustrates a functional diagram of a secure device application architecture for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. As shown, device **110** includes an operating system application space **131**, operating system lower layers **130** including network stack **121**, and access modem (e.g., wireless modem) **129**. As also shown, operating system application space **131** includes various user applications, such as user data application **111** and user voice application **119**, and service usage monitor **119**. Operating system application space **131** also includes secure enterprise mobile services application **125**, which includes various enterprise applications, such as email, synchronization, contacts, calendar communications, and intranet. Secure enterprise mobile services application **125** also includes secure network interface **128** (e.g., for securely communicating with an enterprise network).

FIG. **14** illustrates a functional diagram of another secure device virtual machine architecture for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. FIG. **14** is similar to FIG. **13**, except that in

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FIG. 14 the user applications are executed/stored within virtual machine (VM) #1 consumer application environment 117, and secure enterprise mobile services application 125 is included within virtual machine (VM) #2 secure enterprise application environment 118. Device 110 also includes virtual machine operating system 115 that includes virtual OS instantiation #1 117A for VM #1 consumer application environment 117 and virtual OS instantiation #2 118A for VM #2 secure enterprise application environment 118. As also shown, virtual machine operating system 115 includes virtual machine OS network stack 116.

FIG. 15 illustrates a functional diagram of another secure device hardware execution partition architecture for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. FIG. 15 is similar to FIG. 14, except that in FIG. 15 hardware partitions are provided instead of virtual partitions. As shown, the user applications are executed/stored within user application secured hardware execution partition 105 and secure enterprise mobile services application 125 is included within enterprise application secured hardware execution partition 106. Device 110 also includes secured hardware partition for OS 115 that includes secure hardware partition manager #1 107 for user application secured hardware execution partition 105 and secure hardware partition manager #2 108 for enterprise application secured hardware execution partition 106. As also shown, secured hardware partition for OS 115 includes OS network stack 116.

FIG. 16 illustrates a functional diagram of another secure device service processor architecture for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. As similarly described herein with respect to various embodiments, the device architecture of FIG. 16 includes service processor framework program 139 (e.g., framework space agent/function) and network stack framework components 137 in operating system framework space 133, and service processor kernel program 138 (e.g., kernel space agent/function) and network stack kernel components 135 in operating system kernel space 132. In some embodiments, the service processor functions provide a user interface function to communicate to a user of device 110 whether or not a service usage activity is an approved/authorized service usage activity, or whether it is a disallowed service usage activity for device 110 (e.g., the enterprise has disallowed the usage of device 110 for such service usage activities, such as online gaming and/or certain other online activities or certain long distance calling or voice usage during certain days, such as weekends) or whether such would/will be charged/billed to the user as a consumer under the user's consumer plan. In some embodiments, the service processor functions provide a user interface function to communicate to a user of device 110 an associated cost of certain service usage activities allocated to consumer service usage. In some embodiments, the service processor functions provide a user interface function to communicate to a user of device 110 an associated credit of certain service usage activities allocated to enterprise service usage. In some embodiments, the service processor functions provide a user interface function to communicate to a user of device 110 various other information as described herein with respect to providing an enterprise and consumer allocation for service usage activities. In some embodiments, the service processor shown in FIG. 16 communicates with a service controller, such as described herein with respect to various embodiments.

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Carrier Managed Billing Allocation with Device Mobile Enterprise Services Application Environment and Mobile Services Gateway Server with Service Usage Monitoring in Carrier Network and on Device

FIG. 17 illustrates a functional diagram of another network architecture 400 for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. Network architecture 400 of FIG. 17 is similar to network architecture 302 of FIG. 10, except that as shown in FIG. 17, device 110 also includes service usage monitor 119 (e.g., agent/function) in secure mobile enterprise application environment 120. In some embodiments, service usage monitor 119 performs application monitoring that includes counting application service usage for secure data application 124 and secure voice application 126 (and, in some embodiments, for also counting application service usage for user applications that are not enterprise or secure enterprise applications 124 or 126). In some embodiments, counting application service usage includes counting bytes or network connection time used in communicating via carrier access network 150 during the device's execution of monitored data applications. In some embodiments, counting application service usage includes counting voice network connection time used in communicating via carrier access network 150 during the device's execution of monitored voice applications. In some embodiments, service usage monitor 119 performs application monitoring that further includes classifying application service usage for secure enterprise applications 124, 126 (e.g., classifying various secure enterprise applications 124, 126 and in some embodiments, including ambient services classification/determination, by application/service usage activity such as based on application name or using signed code/hash techniques, by time of day/day of week, enterprise server, destinations, enterprise intranet, and/or other factors).

In some embodiments, carrier usage accounting server 154 communicates (e.g., using secure communication techniques) with service usage monitor 119 to mediate billing/charging and credit reports, for example, using the various approaches and techniques as described herein.

In some embodiments, service usage monitor 119 and/or another function/agent executed in secure mobile enterprise application environment 120 of device 110 blocks user access for non-enterprise activities that the user has not agreed to pay for.

Because the enterprise service usage is monitored by the device network elements in the embodiments depicted in FIG. 17, various service accounting or billing policies are available to the enterprise or carrier. For example, the amount of service usage resulting from enterprise services that occur during roaming conditions may be accounted for even when the carrier network does not receive detailed classification of service usage from roaming network partners. The business rules programmed into service usage reconciliation function 158 that are determined by the enterprise service activity policy set can break-out enterprise service related roaming charges separate from consumer service related roaming charges. In addition, in some embodiments, the device secure mobile enterprise environment includes an access control function so that the access control policies specified in the enterprise service activity policy set can be enforced on roaming networks that have access that is not controlled by the carrier home network.

For example, the allowances provided by the enterprise service activity policy set can be programmed so that the allowances change depending on the availability of a par-

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ticular network or set of networks, the time of day, the congestion state of a network, or the current cost of service on the network. As another example, if the carrier home network is not available and only a roaming network is available, the allowance can be decreased or removed. As yet another example, if a certain network type is not available but another network type is (e.g., 2G is available instead of 3G or 3G is available instead of 4G), then the allocation can be reduced. As yet a further example, if a variable charging policy is in place with the carrier for access when the network is busy or during certain times of day, then the enterprise sponsored allowance can be reduced during times of higher charging. As described herein, in some embodiments, an active network detection function can be included on the device to assist the network policy enforcement to determine the type of network the device is connected to or to determine if the device is on a home or roaming network. As also described herein, in some embodiments, a network busy state monitor function can be included on the device to assist the network policy enforcement to determine the network busy state or state of network congestion.

Carrier Managed Billing Allocation with Device Mobile Enterprise Services Application Environment and Mobile Services Gateway Server with Service Usage Monitoring in Carrier Network, on Device, and in Enterprise Mobile Services Gateway Server

FIG. 18 illustrates a functional diagram of another network architecture 401 for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. Network architecture 401 of FIG. 18 is similar to network architecture 400 of FIG. 17, except that in network architecture 401 of FIG. 18, secure enterprise mobile services gateway/server 172 includes mobile server usage counter 179, and the enterprise service usage reports from this function are sent to service usage reconciliation function 158. In some embodiments, various specialized needs of monitoring, recording, and reporting enterprise service usage are confined to the special-purpose secure enterprise mobile services gateway/server 172.

Enterprise Managed Billing Allocation with Device Mobile Enterprise Services Application Environment and Mobile Services Gateway Server with Service Usage Monitoring on Device and in Enterprise Mobile Services Gateway Server

FIG. 19 illustrates a functional diagram of another network architecture 402 for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. Network architecture 402 of FIG. 19 is similar to network architecture 401 of FIG. 18, except that network architecture 402 of FIG. 19 does not include the service usage feed from carrier gateway/home agent 152, and service usage reconciliation function 158 relies solely on a device service usage feed from device 110 usage monitors 119 and secure enterprise mobile services gateway/server 172 mobile service usage monitor 179. In some embodiments, service usage reconciliation function 158 and enterprise service usage accounting server 159 are under the control of the enterprise or the carrier. For example, an enterprise entity can establish enterprise service and consumer service usage allocation accounting without the need to tie into the carrier network for usage feeds and usage accounting. Using various techniques described herein, an enterprise service usage credit can be determined, and the determined enterprise service usage credit can be reimbursed to the device user.

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Enterprise Managed Billing Allocation with Device Mobile Enterprise Services Application Environment and Mobile Services Gateway Server with Service Usage Monitoring on Device

FIG. 20 illustrates a functional diagram of another network architecture 403 for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. Network architecture 403 of FIG. 20 is similar to network architecture 402 of FIG. 19, except that in network architecture 403 of FIG. 20, service usage reconciliation function 158 receives feeds from device 110 service usage monitors 119 and there is no feed from the secure enterprise mobile services gateway server.

Enterprise Usage Credit with Device Mobile Enterprise Services Application Environment and Mobile Services Gateway Server with Service Usage Monitoring on Device and in Enterprise Mobile Services Gateway Server

FIG. 21 illustrates a functional diagram of another network architecture 404 for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. Network architecture 404 of FIG. 21 is similar to network architecture 402 of FIG. 19, except that in network architecture 404 of FIG. 21, there is no service usage monitor function 119 in user services application environment 122 providing service usage reports/information to service usage reconciliation function 158, and enterprise usage accounting server 159 only generates enterprise usage records 156.

Enterprise Usage Credit with Device Mobile Enterprise Services Application Environment and Mobile Services Gateway Server with Usage Monitoring on Device

FIG. 22 illustrates a functional diagram of another network architecture 405 for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. Network architecture 405 of FIG. 22 is similar to network architecture 404 of FIG. 21, except that network architecture 405 of FIG. 22 does not include mobile server usage monitor 179 providing enterprise service usage reports/information to service usage reconciliation function 158. Device Configurations with Service Usage Monitoring and Reporting

In some embodiments, secure enterprise mobile services application 125 and network stack 121 can be implemented in access modem 129, as described below with respect to FIGS. 23 through 26.

FIG. 23 illustrates a functional diagram of a secure device application architecture with device-based service usage monitoring (and in some embodiments, access control) for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. FIG. 23 is similar to FIG. 13 except that in FIG. 23 usage monitor 119 is provided as shown, and secure enterprise mobile services application 125 and network stack 121 can be implemented in access modem 129 as also shown.

FIG. 24 illustrates a functional diagram of a secure device virtual machine architecture with device-based service usage monitoring (and in some embodiments, access control) for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. FIG. 24 is similar to FIG. 14 except that in FIG. 24, usage monitor 119 is provided as shown, and secure enterprise mobile services application 125 and virtual machine OS network stack 116 can be implemented in access modem 129 as also shown.

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FIG. 25 illustrates a functional diagram of a secure device hardware execution partition architecture with device-based service usage monitoring (and in some embodiments access control) for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. FIG. 25 is similar to FIG. 15 except that in FIG. 25 usage monitor 119 is provided as shown, and secure enterprise mobile services application 125 and virtual machine OS network stack 116 can be implemented in access modem 129 as also shown.

FIG. 26 illustrates a functional diagram of a secure device service processor architecture with device based service usage monitoring (and in some embodiments, access control) for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. FIG. 26 is similar to FIG. 16 except that in FIG. 26 usage monitor 119 is provided as shown, and secure enterprise mobile services application 125, service processor framework 139, and service processor kernel program 138, can be implemented in the access modem 129 as also shown.

In some embodiments, service processor framework program 139 (or service processor kernel program 138) interacts with network stack framework components 137 or network stack kernel components 135 to inspect traffic for service usage classification and service policy enforcement (e.g., access control policy enforcement, traffic control policy enforcement, service usage accounting, charging policy enforcement, or service notification policy enforcement) purposes. In some embodiments, one or more of network stack framework components 137 and network stack kernel components 135 provides classification information on one or more traffic flows to service processor framework program 139 (or service processor kernel program 138). In some embodiments, service processor framework program 139 (or service processor kernel program 138) seeks to match the classification information to one or more classification parameters contained in the service policy definitions in order to determine the service policy enforcement actions that may be required for a traffic flow. In some embodiments, a traffic flow is a flow of data packets. In some embodiments, a traffic flow is a flow of one or more data packets that are associated with a device application, the association of a traffic flow to a device application being identified by network stack framework components 137 or network stack kernel components 135 or service processor framework program 139 (or service processor kernel program 138). In some embodiments, the service usage classification determines that the traffic flow is associated with a combination of one or more of: a device application, a network destination, a traffic type, a content type, a QoS level, a roaming network, a home network.

In some embodiments, the association of traffic flow to a specific device application is used to determine a service policy enforcement action that is dependent on the specific device application. In some embodiments, a specific device application identifier (e.g., an application name, application signature, application hash or application certificate) forms an application credential that is used to index a service policy enforcement action that is intended to be implemented following a service usage activity or attempted service usage activity by the specific device application. In some embodiments, a specific device application is verified as consistent with an application credential in order to ensure that an application service policy enforcement action intended to be applied to the specific device application is applied to the correct application. In some embodiments, the

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verification that a specific application is consistent with an application credential associated with a service policy enforcement action is performed in service processor framework program 139 (or service processor kernel program 138) to ensure that an application service policy enforcement action intended to be applied to the specific device application is applied to the correct application. In some embodiments, the verification that a specific application is consistent with an application credential associated with a service policy enforcement action is performed in network stack framework components 137 or network stack kernel components 135, and service processor framework program 139 (or service processor kernel program 138) ascertains the application credential verification to ensure that an application service policy enforcement action intended to be applied to the specific device application is applied to the correct application.

In some embodiments, the association of traffic flow to a specific device application is used to determine a service policy enforcement action that is dependent on the specific device application, and service processor framework program 139 (or service processor kernel program 138) instructs network stack framework components 137 or network stack kernel components 135 to implement the service policy enforcement action on the traffic flow associated with the specific device application. In some embodiments, the association of traffic flow to a specific device application is used to determine a service policy enforcement action that is dependent on the specific device application, and service processor framework program 139 (or service processor kernel program 138) implements the service policy enforcement action. In some embodiments, a traffic flow is buffered pending classification (e.g., buffered in one or more of network stack framework components 137, network stack kernel components 135, service processor framework program 139, or service processor kernel program 138). In some embodiments, upon classification of the traffic flow (e.g., determination of an association of the traffic flow to a specific device application), a service policy enforcement action that is dependent on the specific device application is determined by service processor framework program 139 (or service processor kernel program 138) and implemented in one or more of network stack framework components 137, network stack kernel components 135, service processor framework program 139, and service processor kernel program 138. In some embodiments, the service policy enforcement action for the traffic flow is implemented in service processor framework program 139 (or service processor kernel program 138). In some embodiments, service processor framework program 139 (or service processor kernel program 138) instructs a device UI program that displays a device service notification (e.g., a service usage notification, a service plan offer notification, or an indication of a service usage event or attempted service usage event that requires a user notification) to implement the service policy enforcement action for the traffic flow. In some embodiments, service processor framework program 139 (or service processor kernel program 138) instructs a service usage monitor (e.g., accounting traffic to bulk classification or a more detailed classification of service usage) to implement the service policy enforcement action for the traffic flow.

In some embodiments, the network destination of a traffic flow is used to determine if a service policy enforcement action that is dependent on a specific network destination should be applied to the traffic flow. In some embodiments, a traffic flow is inspected by network stack framework components 137 or network stack kernel components 135,

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and one or more traffic characteristics (e.g., an address, a socket/flow tuple, a layer-7 packet information, or a packet header string) are passed to service processor framework program 139 (or service processor kernel program 138), wherein the one or more traffic characteristics are matched against one or more classification parameters contained in a service policy definition, and if a match is present then a service policy enforcement action is implemented for the traffic flow. In some embodiments, a traffic flow is inspected by service processor framework program 139 (or service processor kernel program 138), and one or more traffic characteristics (e.g., an address, a socket/flow tuple, a layer-7 packet information, or a packet header string) are matched against one or more classification parameters contained in a service policy definition, and if a match is present then a service policy enforcement action is implemented for the traffic flow. In some embodiments, the service policy enforcement action for the traffic flow is implemented in service processor framework program 139 (or service processor kernel program 138). In some embodiments, service processor framework program 139 (or service processor kernel program 138) instructs network stack framework components 137 or network stack kernel components 135 to implement the service policy enforcement action for the traffic flow. In some embodiments, the service policy enforcement action for the traffic flow is implemented by a device UI program that displays a device service notification (e.g., a service usage notification, a service plan offer notification, or an indication of a service usage event or attempted service usage event that requires a user notification). In some embodiments, the service policy enforcement action for the traffic flow is implemented by a service usage monitor (e.g., accounting traffic to bulk classification or a more detailed classification of service usage).

In some embodiments, an enterprise manager can define or select service plan policies that confine enterprise-sponsored access services to a pre-defined list of device applications. For example, an enterprise manager might choose to define or select a service plan wherein only corporate applications may be accessed (e.g., email, contacts, intranet services, text, and/or voice). In such embodiments, enterprise service design user interface 196 may be used by the enterprise manager to define or select the allowable applications that are to have access. In some embodiments, an enterprise access manager may define or select a different set of applications to be accessible when device 110 is roaming than when device 110 is on a home network or on a WiFi network. In some embodiments, an enterprise manager may define or select a set of applications that are to be not allowed access when a device is on a certain network (e.g., a roaming network). For example, many modern smart phone, tablet, and laptop operating systems have background services that have the potential to incur large roaming charges during roaming conditions (e.g., Google Android “gallery” functions that share device data with the Google network, Microsoft “system” functions that do the same, software update programs, etc.). In such cases, enterprise service design center 194 may be used to specify the device applications that are not allowed to access the network during certain network conditions.

In some embodiments, the identification and network access control for a device application is performed with a device software program or agent (e.g., service processor framework program 139 or service processor kernel program 138), and enterprise service design center 194 programs the device agent with the application identification parameters and associated access policies. In some embodi-

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ments, the device agent identifies the application using an application name, certificate, signature, or hash for an application running on the device and a policy instruction stored on the device.

In some embodiments, the identification and network access control for a device application is performed with one or more network access policy enforcement elements (e.g., carrier gateway/home agent 152, carrier usage accounting server 154, enterprise firewall/security gateway 171), and enterprise service design center 194 causes the one or more network access policy enforcement elements to be provisioned with the application identification parameters and associated access policies. In some embodiments, the one or more network access policy enforcement elements identify an application by observing the traffic headers inserted by the application. In some embodiments, the one or more network access policy enforcement elements identify an application by observing the network destinations or destination patterns accessed by the application. In some embodiments, the one or more network access policy enforcement elements identify an application by routing or tunneling the application traffic to one or more network gateways or servers associated with the application (e.g., APN routes, dedicated application addressing, or a device agent that steers the application traffic to a server). In some embodiments, the device assists in this routing or tunneling with a device agent that is programmed to route or re-direct the traffic for an application.

In some embodiments, an enterprise manager can define or select service plan policies that confine enterprise-sponsored access services to a pre-defined list of network destinations, servers, or resources. For example, an enterprise manager might choose to define or select a service plan wherein only corporate network destinations may be accessed (e.g., email server, contacts server, intranet servers, text service servers, and VOIP servers). In some embodiments, enterprise service design center interface 196 may be used by an enterprise manager to define or select the allowable network destinations that device 110 may access. In some embodiments, the enterprise access manager may define or select a different set of network destinations when device 110 is roaming than when device 110 is on a home network or on a WiFi network. In some embodiments, an enterprise manager may define or select a set of network destinations that device 110 cannot access when device 110 is on a certain network (e.g., a roaming network). For example, many websites and enterprise services exhibit network access service usage behavior that can incur large roaming charges during roaming conditions (e.g., software update websites or servers, contact database synchronization websites, email download synchronization websites, video conference websites, etc.). In such cases, enterprise service design center 194 may be used to specify the device applications, services, and/or websites that are not to be accessed or used during certain network connection conditions.

In some embodiments, a device agent identifies the network destination and applies the appropriate access policy by comparing traffic characteristics with pre-defined characteristics in the access policy instructions provisioned on device 110, and then applies the corresponding traffic control rule, and enterprise service design center 194 performs the provisioning of the device agent. In some embodiments, the identification and network access control for a network destination is performed with one or more network access policy enforcement elements (e.g., carrier gateway/home agent 152, carrier usage accounting server 154, enterprise

firewall/security gateway 171) and enterprise service design center 194 performs the provisioning of the one or more network elements.

In some embodiments, enterprise service design center 194 is configured to receive or accept a specification for an access network service usage limit (e.g., a service amount in minutes, bytes, or cost) for a service usage activity (such as a data service, a voice service, a text service, a roaming service, or a more detailed classification of data service such as one or more websites or one or more device applications), and the service usage limit is applied to one or more devices 110 or device groups (or users or user groups) managed by enterprise service design center 194. In some embodiments, enterprise service design center 194 is further configured to receive service usage records for device 110, which is managed by enterprise service design center 194, from a device-based element that monitors and reports device 110 service usage (e.g., one or more device usage monitors 119, device service processor framework program 139, or service processor kernel program 138, network stack 134, or access modem 151), and when the usage limit is reached a service usage notification message is generated. In some embodiments, enterprise service design center 194 is configured to deliver the service usage notification message to enterprise service design center UI 196. In some embodiments, enterprise service design center 194 is configured to deliver the service usage notification message to a device 110 software application (e.g., service processor framework program 139 or user data app 111) for presentation to the device user via a user interface.

In some embodiments, enterprise service design center 194 is configured to receive or accept a specification for an access network service usage limit (e.g., a service amount in minutes, bytes, or cost) for a service usage activity (such as a data service, a voice service, a text service, a roaming service, or a more detailed classification of data service such as one or more websites or one or more device applications), and the service usage limit is applied to one or more devices 110 or device groups (or users or user groups) managed by enterprise service design center 194. In some embodiments, enterprise service design center 194 is further configured to receive service usage records for device 110, which is managed by the enterprise service design center 194, from a device-based element configured to monitor and report device 110 service usage (e.g., one or more device usage monitors 119, device service processor framework program 139 or service processor kernel program 138, network stack 134, or access modem 151), and when the usage limit is reached a restriction or limitation on further usage is applied by the service design center by provisioning one or more network elements responsible for enforcing network access policy (e.g., carrier gateway/home agent 152, carrier usage accounting server 154, enterprise firewall/security gateway 171). In some embodiments, enterprise service design center 194 is configured to send the user a notification message or a message to contact an enterprise manager.

In some embodiments, secure network interface 128 on device 110 is configured with a VPN device client function to securely communicate between one or more approved enterprise applications (e.g., enterprise data app 124, enterprise voice app 126, secure enterprise mobile services app 125) and a counterpart VPN function that secures access to enterprise network 170 (e.g., enterprise firewall/security gateway 171 or server secure network interface 127). In some embodiments, a device software application or agent (e.g., service processor framework program 139 or service processor kernel program 138, secure network interface 128,

secure hardware partition manager 108) is configured to identify network access activity associated with individual applications and allow network access to one or more approved enterprise applications when a VPN device client function is in operation, or not allow network access to one or more approved enterprise applications when a VPN device client function is not in operation. In some embodiments, service design center 190 or enterprise service design center 194 is configured to provision a device 110 software application or agent (e.g., service processor framework program 139 or service processor kernel program 138, secure network interface 128, secure hardware partition manager 108) with application access policy rules to identify network access activity associated with individual applications and allow network access to one or more approved enterprise applications when a VPN device client function is in operation, or not allow network access to one or more approved enterprise applications when a VPN device client function is not in operation. In this manner, enterprise applications that might be subject to spoofing by network elements, websites, servers, or programs operating outside the secure enterprise environment are not placed in communication with such network elements.

In some embodiments, a device software application or agent (e.g., service processor framework program 139 or service processor kernel program 138, secure network interface 128, secure hardware partition manager 108) is configured to identify network access activity associated with individual applications and not allow network access to one or more non-approved applications when a VPN device client function is in operation, or allow network access to one or more non-approved applications when a VPN device client function is not in operation. In some embodiments, service design center 190 or enterprise service design center 194 is configured to provision a device 110 software application or agent (e.g., service processor framework program 139 or service processor kernel program 138, secure network interface 128, secure hardware partition manager 108) with application access policy rules to identify network access activity associated with individual applications and not allow network access to one or more non-approved applications when a VPN device client function is in operation, or allow network access to one or more enterprise applications when a VPN device client function is not in operation. In this manner, applications that might maliciously access enterprise network resources when the VPN is running are not permitted to do so.

In some embodiments, the application access policy rules are enforced by allowing or not allowing an application to access the network. In some embodiments, the application access policy rules are enforced by allowing or not allowing the application to run. In some embodiments, the identification of approved enterprise applications associated with traffic flows is confirmed or secured by identifying the application certificate and comparing it to an application signature or hash on the device. In some embodiments, the identity of an approved enterprise application is confirmed by inspecting an application certificate, signature or hash that is provided by service design center 190 or enterprise service design center 194.

In some embodiments, secure network interface 128 is configured with a split-tunnel VPN device client function, wherein an enterprise side of the split tunnel is configured to securely communicate between one or more enterprise applications (e.g., enterprise data app 124, enterprise voice app 126, secure enterprise mobile services app 125) and a counterpart VPN function that secures access to the enter-

prise network 170 (e.g., enterprise firewall/security gateway 171 or server secure network interface 127), and a consumer side of the split tunnel is configured to communicate without encryption for access network services provided to consumer applications on the device. In some embodiments, a device software application or agent (e.g. service processor framework program 139 or service processor kernel program 138, secure network interface 128, secure hardware partition manager 108) is configured to identify network access activity associated with individual applications and route or direct traffic associated with one or more enterprise applications to the enterprise side of the split VPN tunnel, and route or direct traffic associated with one or more consumer applications to the consumer side of the VPN tunnel. In some embodiments, service design center 190 or enterprise service design center 194 is configured to provision a device 110 software application or agent (e.g., service processor framework program 139 or service processor kernel program 138, secure network interface 128, secure hardware partition manager 108) with application access policy rules to identify network access activity associated with individual applications and specify which applications are to be routed or directed to the enterprise side of the VPN tunnel and which applications are to be routed or directed to the consumer side of the VPN tunnel. In some embodiments, the identification of applications associated with traffic flows is secured by identifying the application certificate and comparing it to an application signature or hash on the device. In some embodiments, the application certificate, signature or hash is provided by service design center 190 or enterprise service design center 194.

In some embodiments, the policy rules only enable secure applications on device 110 to access enterprise data. In some embodiments, an enterprise manager sets policy rules that do not allow secure applications on device 110 to upload data to unsecure destinations.

In some embodiments, service design center 190 is configured to provide enterprise service design center 194. In some embodiments, enterprise service design center 194 comprises a policy management system configured to select a set of access network policies to be enforced for one or more device groups (or user groups) where the set of access network policies consists of a subset of the full set of access network policies capable of being enforced by the access network policy enforcement elements. In some embodiments, the subset of the full set of policies capable of being enforced by the access network policy enforcement elements comprises a pre-defined subset of the policy configuration capabilities. In some embodiments, the enterprise service design center policy management subset limitations for enterprise service design center 194 provide the ability to define and manage one or more of the policies that define a service policy set or service plan that is applied to a given device, user, device group or user group. In some embodiments, the enterprise service design center policy management subset limitations for enterprise service design center 194 can provide the ability to enroll a device, user, device group or user group in a set limited to one or more pre-defined service policy configurations or service plans.

As an example embodiment, the enterprise service design center policy management subset limitations for enterprise service design center 194 may provide the following policy definition and management capabilities for a device (or user) or device group (or user group): specify service usage limits (caps) for bulk access service or for a specific classification of access service activities, require all traffic or certain traffic associated with enterprise-critical applications or content to

be communicated via an enterprise VPN, define controls for which applications that can access the network or certain defined destinations on the network, specify network destinations that are allowed or not allowed, specify roaming service limitations, specify WiFi networks that are allowed or not allowed, specify security settings in the device access control or I/O access control ports, specify service usage notification triggers and notification content associated with the triggers (e.g., warnings when a specified service usage activity occurs, access is not allowed for a given attempted service usage activity, or service usage reaches a limit), and other such examples that are allowed to be managed under the policy management subset limitations. In some embodiments, the charging rates for such services may not be allowed to be managed under the policy management subset limitations.

In some embodiments, enterprise service design center 194 has an allowable subset of the full set of policies capable of being enforced by the access network policy enforcement elements that comprises a pre-defined set of one or more access network policy configurations (e.g., service plans). As an example embodiment, the set of pre-configured service plans may be defined for a certain implementation of enterprise service design center 194 comprising multiple pre-defined service plans, each of which provides variations in one or more of service notification policy, access control policy, service classification policy, service QoS policy, or service charging policy.

In some embodiments, enterprise service design center 194 is configured to allow a service design administrator to select one or more pre-configured access network policy configurations (or service plans) to be applied to a device, a user, a device group or a user group.

In some embodiments, enterprise service design center 194 comprises a device enrollment management system configured to enroll a device credential into a device group (or a user credential into a user group), where the set of device credentials (or user credentials) that enterprise service design center 194 is capable of managing is a subset of the device credentials (or user credentials) allowed on the access network. In some embodiments, the subset of device credentials (or user credentials) that are subject to management by enterprise service design center 194 is defined using service design center 190.

As an example embodiment, the set of pre-defined service plans that are made available to a first enterprise service design center 194 implementation managed by a first enterprise entity might consist of three service plans, wherein the first service plan comprises network policies (e.g., access policies, charging policies, or notification policies) that provide for limited or restricted home network access service but do not provide for roaming access services, the second service plan comprises network policies that provide for unlimited or unrestricted home network access service and also provide for limited roaming access services, and the third service plan comprises network policies that provide for unlimited or unrestricted home network access service and also provide for unlimited or unrestricted roaming access services. In another example embodiment, on the same carrier access network as the previous example, a second enterprise service design center 194 implementation managed by a second enterprise entity might consist of two service plans, wherein the two service plans might be the same as two of the service plans from the previous example embodiment, or they might be completely different.

Given these examples, it will now be understood and appreciated by one of ordinary skill in the art that enterprise

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service design center **194** provides a convenient means of designing and distributing custom service plans to different enterprise entities that meet the needs of each enterprise entity, wherein the various policy definition capabilities disclosed herein can be used in a large number of combinations to create the service plans, with the number of combinations of service plan design capabilities being too numerous to list here. It will also now be understood and appreciated by one of ordinary skill in the art that each enterprise can effectively manage its devices (or users) and device groups (or user groups) to provide the appropriate level of policy control needed by the enterprise in a simplified manner, without the need to manage all the full policy capabilities of the access network.

For example, the embodiments of service design center **190** and enterprise service design center **194** disclosed herein support a carrier network business process wherein a carrier network manager utilizes service design center **190** to create a set of access network policies that consist of a subset of the full set of access network policies capable of being enforced by the access network policy enforcement elements (referred to as specialized enterprise service plans), and the specialized enterprise service plans are designed and offered to meet the special needs of one or more enterprise entities. In some embodiments, an enterprise manager uses enterprise service design center **194** to apply the one or more specialized enterprise service plans to one or more devices (or users) or device groups (or user groups) that belong to the enterprise entity's mobile device inventory (or employee list). The different needs of various employee groups (or device types) can be among the factors that determine which service plan is assigned to a given user group (or device group). The specific needs of an employee can assist in determining which user group (or device group) the employee should be assigned to. The carrier manager can also create other specialized enterprise service plans for other enterprise entities to meet varied needs among enterprise market customers.

In some embodiments, an enterprise manager controls access network usage, costs, and access limits for an employee user group (e.g., a group of devices that could be as small as a single device or as large as all devices under the enterprise manager's control). In some embodiments, the enterprise manager establishes at least two user groups and establishes and manages different network-access policies for different employee user groups. For example, the enterprise manager may set and manage different policies for data usage on WiFi, 3G, 4G, or other networks for different employee user groups. Likewise, the enterprise manager may set different roaming privileges for different employee user groups.

In some embodiments, an enterprise manager sets expenditure ceilings by limiting allowed data usage for secure business applications to enforce security rules. In some embodiments, an enterprise manager tracks enterprise data access to improve compliance records. For example, the enterprise manager can track enterprise data usage by employee, device, application, location, network, or time of day.

Process Flows for Providing Enterprise and Consumer Billing Allocation for Wireless Communication Device Service Usage Activities

FIG. **27** illustrates a flow diagram for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. At **402**, the process begins. At **404**, a service usage activity of a wireless communication device (e.g.,

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application based service usage that uses a wireless network in which the wireless communication device has an associated service plan) is performed. In some embodiments, the monitoring is performed on the wireless communication device. In some embodiments, the monitoring is performed by a network element, such as a secure application server for monitoring enterprise applications, as described herein with respect to various embodiments. At **406**, an enterprise/consumer allocation is determined. In some embodiments, the monitored service usage activity is reported to a network element that determines the enterprise/consumer allocation based on the associated service plan that includes a defined enterprise/consumer allocation based on various factors, such as can be performed by a carrier billing server as described herein with respect to various embodiments. At **408**, an associated consumer account is billed for the consumer service usage. At **410**, the consumer account is credited for the enterprise service usage. At **412**, the process is completed.

FIG. **28** illustrates another flow diagram for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. At **502**, the process begins. At **504**, a service usage activity of a wireless communication device (e.g., application based service usage that uses a wireless network in which the wireless communication device has an associated service plan) is performed. At **506**, an enterprise/consumer allocation is determined. At **508**, an associated enterprise account is billed for the enterprise service usage. At **510**, the enterprise account is credited for the consumer service usage. At **512**, the process is completed.

FIG. **29** illustrates another flow diagram for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. At **602**, the process begins. At **604**, a service usage activity of a wireless communication device (e.g., application based service usage that uses a wireless network in which the wireless communication device has an associated service plan) is performed. At **606**, an enterprise/consumer allocation is determined. At **608**, the enterprise service usage is reported. At **610**, an expense reimbursement for the enterprise service usage is generated (e.g., by the enterprise for the consumer, who is, for example, an employee of the enterprise). At **612**, the process is completed.

FIG. **30** illustrates another flow diagram for providing enterprise and consumer billing allocation for wireless communication device service usage activities in accordance with some embodiments. At **702**, the process begins. At **704**, a service usage activity of a wireless communication device (e.g., application based service usage that uses a wireless network in which the wireless communication device has an associated service plan) is performed. At **706**, the monitored service usage is reported. At **708**, an enterprise/consumer allocation is determined. At **710**, a bill/charge based on the enterprise/consumer allocation is generated. At **712**, the process is completed.

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. In particular, many of the embodiments are not limited to supporting an enterprise/consumer split. As would be appreciated by one of ordinary skill in the art, the disclosed embodiments may be applied, for example, when a sponsor entity subsidizes a cost associated with an end-

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user device's use of a sponsored (or ambient) data service or application, and the user pays for the end-user device's use of non-sponsored (or non-ambient) data services or applications. The sponsor entity may use enterprise service design center 194 to configure devices that may use the sponsored service, policies applicable to the sponsored service, etc. Moreover, the disclosed embodiments may be applied when a first sponsor subsidizes a cost associated with an end-user device's use of a first sponsored data service or application, a second sponsor subsidizes a cost associated with the end-user device's use of a second sponsored data service or application, and the user pays for the end-user device's use of non-sponsored data services or applications. The sponsor entities may use one or more enterprise service design centers to configure aspects of the sponsored services. As would be appreciated by one of ordinary skill in the art, there are many other environments in which the disclosed embodiments are useful or applicable.

Several advantageous combination embodiments are now disclosed for allocating enterprise service usage accounting and personal service usage accounting. These combinations are for example purposes, are not meant to be exhaustive or limiting in any way; as will be apparent to one of ordinary skill in the art, these combinations represent only a fraction of the embodiments provided herein.

In some embodiments, a network system for classifying the accounting of access network service usage for an end user device comprises (i) a first service design center configured to receive an accounting split classification policy defining the classification rules for dividing an overall access network service usage into an enterprise service usage allocation and a personal service usage allocation, (ii) a network provisioning instruction translator configured to receive the accounting split classification policy and translate it to a set of network service usage classification and reporting instructions for one or more network elements responsible for classifying service usage, (iii) a network provisioning system for communicating the set of network service usage classification and reporting instructions to the one or more network elements responsible for classifying service usage, (iv) the one or more network elements responsible for classifying service usage configured to classify service usage to determine the enterprise service usage allocation and the personal service usage allocation, and generate service usage reports, and (v) a service usage accounting system that receives the service usage reports and (a) accrues the enterprise service usage allocation, and (b) accrues the personal service usage allocation.

In some embodiments, the network system for classifying the accounting of access network service usage for an end user device can be augmented wherein the first network access notification message policy is associated with a first device group defined by a first list of device credentials or a first user group defined by a first list of user credentials, and the service design center is further configured to obtain a second network access notification message policy comprising a plurality of second network access trigger conditions and, for each of the plurality of second network access trigger conditions, an associated second network access notification message, the second network access notification message policy associated with a second device group defined by a second list of device credentials or a second user group defined by a second list of user credentials.

In some embodiments, the network system for classifying the accounting of access network service usage for an end user device further comprises a master service design center

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configured to define a first notification policy design capability set for the first service design center, the first notification policy design capability set comprising a first subset of a master policy capability set. This embodiment can be further augmented wherein the master service design center is further configured to define a second notification policy design capability set for a second service design center, the second notification policy design capability set comprising a second subset of the master policy capability set, the second subset of the master policy capability set either identical to or different from the first subset of the master policy capability set.

In some embodiments, the network system for classifying the accounting of access network service usage for an end user device is further augmented wherein the first service design center is hosted on an operator network. In some embodiments, the network system for classifying the accounting of access network service usage for an end user device is optimized for smaller enterprise data center deployments wherein the first service design center is hosted on an enterprise business network.

In some embodiments, the network system for classifying the accounting of access network service usage for an end user device can be augmented wherein the enterprise service usage allocation comprises a classification of service usage that specifies one or more enterprise device software applications. In some embodiments, the enterprise applications can be one or more of email, calendar, contacts, enterprise intranet (e.g., a secure intranet browser with a secure SSL connection or other secure connection to enterprise services), mobile device synchronization or mobile enterprise communications.

In some embodiments, the network system for classifying the accounting of access network service usage for an end user device can be augmented wherein the enterprise service usage allocation comprises a classification of service usage that specifies one or more enterprise network destinations.

In some embodiments, the network system for classifying the accounting of access network service usage for an end user device can be augmented wherein the enterprise service usage allocation comprises a classification of service usage that specifies one or more enterprise network destinations and the one or more enterprise network destinations comprise an address or identifier for a secure enterprise gateway. In some embodiments, the enterprise gateway comprises a VPN server.

In some embodiments, the network system for classifying the accounting of access network service usage for an end user device can be augmented wherein the enterprise service usage allocation comprises a classification of service usage that specifies one or more enterprise network destinations and the one or more enterprise network destinations comprise an address or identifier for one or more secure enterprise mobile services gateways or servers comprising one or more of an email server, a calendar server, a contacts server, an enterprise intranet access server, a mobile device synchronization services server or a mobile enterprise communication server.

In some embodiments, the network system for classifying the accounting of access network service usage for an end user device can be augmented wherein the one or more network elements responsible for classifying service usage and generating service usage reports comprises a service usage monitor located in a wireless operator network.

In some embodiments, the network system for classifying the accounting of access network service usage for an end user device can be augmented wherein the one or more

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network elements responsible for classifying service usage and generating service usage reports comprises a service usage monitor located in an enterprise access network.

In some embodiments, the network system for classifying the accounting of access network service usage for an end user device can be augmented wherein the one or more network elements responsible for classifying service usage and generating service usage reports comprises a service usage monitor located on a wireless device.

In some embodiments, the network system for classifying the accounting of access network service usage for an end user device can be augmented wherein the service usage accounting system is located in an enterprise network.

In some embodiments, the network system for classifying the accounting of access network service usage for an end user device can be augmented wherein the service usage accounting system is managed by an enterprise manager under the control of the entity that manages an enterprise business.

In some embodiments, the network system for classifying the accounting of access network service usage for an end user device can be augmented wherein the service usage accounting system is located in an operator network.

In some embodiments, the network system for classifying the accounting of access network service usage for an end user device can be augmented wherein the service usage accounting system is managed by an operator manager under the control of the entity that manages a network operator.

In some embodiments, the network system for classifying the accounting of access network service usage for an end user device can be augmented wherein the service usage accounting system is further configured to credit a user account with a service usage credit or monetary credit associated with the accrued enterprise service usage allocation.

In some embodiments, the network system for classifying the accounting of access network service usage for an end user device can be augmented wherein the service usage accounting system is further configured to debit a user account with a service usage debit or monetary cost associated with the accrued personal service usage allocation.

In some embodiments, the network system for classifying the accounting of access network service usage for an end user device can be augmented wherein the service usage accounting system is further configured to credit an enterprise account with a service usage credit or monetary credit associated with the accrued personal service usage allocation.

In some embodiments, the network system for classifying the accounting of access network service usage for an end user device can be augmented wherein the service usage accounting system is further configured to debit an enterprise account with a service usage debit or monetary cost associated with the accrued enterprise service usage allocation.

In some embodiments, the network system for classifying the accounting of access network service usage for an end user device can be augmented by further configuring the service design center to: (i) receive a personal service plan offer comprising one or more service plans for personal network access services accounted to the personal service usage allocation, (ii) configure a device user interface service plan offer notification message, (iii) communicate the device user interface service plan offer notification message to one or more device groups comprising a collection of devices identified by device credentials, (iv) receive a ser-

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vice plan selection option from an end user device user in response to the device user interface service plan offer notification message, and (v) cause one or more network elements responsible for activating service plans to activate the service plan selection chosen by the end user device user.

In some embodiments the end-user device system in communication with the network system for classifying the accounting of access network service usage comprises: (i) a device software application execution environment comprising: (a) an enterprise application execution environment configured with: (1) an enterprise application execution memory and data memory to support secure execution of enterprise software applications, the enterprise software applications comprising applications approved to execute in the secure execution environment and to communicate with secure enterprise services, (2) a secure enterprise communication link configured to provide communication between the enterprise software applications and enterprise network services, the enterprise network services comprising enterprise network resources and servers, (b) a personal application execution environment configured with execution memory and data memory to support execution of personal software applications not approved to execute in the secure execution environment, (ii) a personal service plan selection user interface comprising a notification software agent configured to receive personal service plan offer from a network element and display the service plan offers, the personal service plan offer comprising one or more service plans for personal network access services accounted to a personal service usage allocation, and receive a service plan selection option from an end user device user and forward the service plan selection option to a network element.

In some embodiments, the end-user device system can be augmented wherein the secure enterprise communication link comprises a VPN client in communication with an enterprise VPN gateway.

In some embodiments, the end-user device system can be augmented wherein the enterprise network services comprise access to one or more secure enterprise mobile services gateways or servers comprising one or more of an email server, a calendar server, a contacts server, an enterprise intranet access server, a mobile device synchronization services server or a mobile enterprise communication server.

In some embodiments, the end-user device system can be augmented wherein the enterprise application execution environment is further configured to: (i) acquire a device software application signature prior to allowing execution of the device software application in the virtual machine operating environment, (ii) compare the signature to an approved list of signatures, (iii) allow the application to execute if it is on the list, and (iv) not allow the application to execute if it is not on the list.

In some embodiments, the end-user device system can be augmented wherein enterprise application execution environment comprises a virtual machine operating environment.

In some embodiments, the end-user device system can be augmented wherein enterprise application execution environment comprises a secure CPU hardware execution partition.

In some embodiments, the end-user device system can be augmented wherein enterprise application execution environment comprises a secure operating system execution partition.

In some embodiments, the end-user device system can be augmented wherein enterprise application execution environment comprises a secure memory area protected by an

enterprise application software program that encrypts the enterprise data stored on device memory and runs a secure encrypted communication protocol for communication with a secure mobile enterprise services gateway server.

Several advantageous combination embodiments are now disclosed for providing enterprise control of network access service to an end user device. These combinations are for example purposes, are not meant to be exhaustive or limiting in any way; as would be appreciated by one of ordinary skill in the art, these combinations represent only a fraction of the advantageous embodiment combinations provided herein.

In some embodiments, a network system for providing network access service control for an end user device comprising: (i) a first service design center configured to receive from an administrator user or a configuration file a first network access policy comprising a first set of network access service permissions associated with an end user device or end user device user, (ii) a network provisioning instruction translator configured to receive the first network access policy and translate it to a set of network access policy enforcement instructions for one or more network elements responsible for controlling network access, (iii) a network provisioning system for communicating the set of network access policy enforcement instructions to the one or more network elements responsible for controlling network access, (iv) the one or more network elements responsible for controlling network access configured to execute the set of network access policy enforcement instructions to enforce network access service permissions and limits.

In some embodiments, the network system for providing network access service control can be augmented wherein the first network access policy is associated with a first device group defined by a first list of device credentials or a first user group defined by a first list of user credentials, and the service design center is further configured to obtain a second network access policy comprising a second set of network access service permissions and, the second network access policy associated with a second device group defined by a second list of device credentials or a second user group defined by a second list of user credentials.

In some embodiments, the network system for classifying the accounting of access network service usage for an end user device further comprises a master service design center configured to define a first network access policy design capability set for the first service design center, the first network access policy design capability set comprising a first subset of a master policy capability set. This embodiment can be further augmented wherein the master service design center is further configured to define a second network access policy design capability set for a second service design center, the second network access policy design capability set comprising a second subset of the master policy capability set, the second subset of the master policy capability set either identical to or different from the first subset of the master policy capability set.

In some embodiments, the network system for providing network access service control can be augmented wherein the first network access policy defines a set of one or more service usage limits or service cost limits.

In some embodiments, the network system for providing network access service control can be augmented wherein the first network access policy defines a set of one or more roaming network service usage limits or service cost limits.

In some embodiments, the network system for providing network access service control can be augmented wherein the first network access policy defines a set of one or more network type restrictions, wherein a network type comprises

one or more of a cellular network, a 2G network, a 3G network, a 4G network, a WiFi network, a particular WiFi network APN, roaming cellular network, a particular cellular operator network.

In some embodiments, the network system for providing network access service control can be augmented wherein the first network access policy defines a set of one or more device application software network access restrictions.

In some embodiments, the network system for providing network access service control can be augmented wherein the first network access policy defines a set of one or more network destination access restrictions.

In some embodiments, the network system for providing network access service control can be augmented wherein the first network access policy defines a set of one or more enterprise network destination allowances or restrictions.

In some embodiments, the network system for providing network access service control can be augmented wherein the first network access policy defines a set of one or more enterprise network destination allowances or restrictions communicated over a secure VPN communication link.

In some embodiments, the network system for providing network access service control can be augmented wherein the first network access policy defines a set of one or more application or network destination allowances or restrictions communicated over a non-secure communication link.

In some embodiments, the network system for providing network access service control can be augmented wherein the first network access policy defines a set of one or more personal application or network destination allowances or restrictions.

In some embodiments, the network system for providing network access service control can be augmented wherein the first network access policy defines a set of one or more geographic location allowances or restrictions.

In some embodiments, the network system for providing network access service control can be augmented wherein the one or more network elements responsible for controlling network access comprises a service usage monitor located in a wireless operator network.

In some embodiments, the network system for providing network access service control can be augmented wherein the one or more network elements responsible for controlling network access comprises a service usage monitor located in an enterprise access network. In some embodiments, the one or more network elements responsible for controlling network access comprises a service usage monitor located in an enterprise access network comprise a VPN gateway wherein all device traffic is communicated from the device to the VPN gateway configured to control the device traffic. In some embodiments, the VPN gateway performs service usage classification to identify and control enterprise traffic. In some embodiments, the VPN gateway performs service usage classification to identify and control personal traffic.

In some embodiments, the network system for providing network access service control can be augmented wherein the one or more network elements responsible for controlling network access comprises a service usage monitor located on a wireless device.

INCORPORATION BY REFERENCE

The following U.S. applications are hereby incorporated by reference for all purposes: application Ser. No. 13/248, 028, filed Sep. 28, 2011, entitled ENTERPRISE ACCESS CONTROL AND ACCOUNTING ALLOCATION FOR

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ACCESS NETWORKS; application Ser. No. 12/380,780, entitled AUTOMATED DEVICE PROVISIONING AND ACTIVATION, filed Mar. 2, 2009; application Ser. No. 12/380,778, filed Mar. 2, 2009, entitled VERIFIABLE DEVICE ASSISTED SERVICE USAGE BILLING WITH INTEGRATED ACCOUNTING, MEDIATION ACCOUNTING, AND MULTI-ACCOUNT; Provisional Application No. 61/206,354, entitled SERVICES POLICY COMMUNICATION SYSTEM AND METHOD, filed Jan. 28, 2009; Provisional Application No. 61/206,944, entitled SERVICES POLICY COMMUNICATION SYSTEM AND METHOD, filed Feb. 4, 2009; Provisional Application No. 61/207,393, entitled SERVICES POLICY COMMUNICATION SYSTEM AND METHOD filed Feb. 10, 2009; Provisional Application No. 61/207,739, entitled SERVICES POLICY COMMUNICATION SYSTEM AND METHOD filed Feb. 13, 2009; and Provisional Application No. 61/387,243, entitled ENTERPRISE AND CONSUMER BILLING ALLOCATION FOR WIRELESS COMMUNICATION DEVICE SERVICE USAGE ACTIVITIES filed Sep. 28, 2010.

The invention claimed is:

1. A method of operating a wireless end-user device, the method comprising:

storing secure policy information indicative of an application-specific execution environment policy and a configurable communication security policy;

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based on the secure stored information indicative of an application-specific execution environment policy, allowing a first set of multiple device application instances to run only in a first secure application environment on the wireless end-user device, and allowing a second set of device application instances to run only outside of the first secure application environment; and

based on the secure stored information indicative of a configurable communication security policy, initiate a first secure tunnel to a network tunnel endpoint, and direct all network data communications to and from device application instances executing in the first secure application environment through the first secure tunnel.

2. The method of claim 1, wherein the configurable communication security policy defines a first configuration, which indicates that application instances in the second set of device application instances are not allowed to use the first secure tunnel, the method further comprising, based on the secure stored information indicative of a configurable communication security policy indicating the first configuration, directing all network data communications to and from device application instances executing outside of the first secure application environment through a network path outside of the first secure tunnel.

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