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Zhu

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(54) **USER PLANE LOCATION BASED SERVICE
USING MESSAGE TUNNELING TO SUPPORT
ROAMING**

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(56) **References Cited**

U.S. PATENT DOCUMENTS

1,103,073 A 7/1914 O'Connell

4,494,119 A 1/1985 Wimbush

(Continued)

OTHER PUBLICATIONS

International Search Report received in PCT/US2011/02001 dated
Apr. 27, 2012.

(Continued)

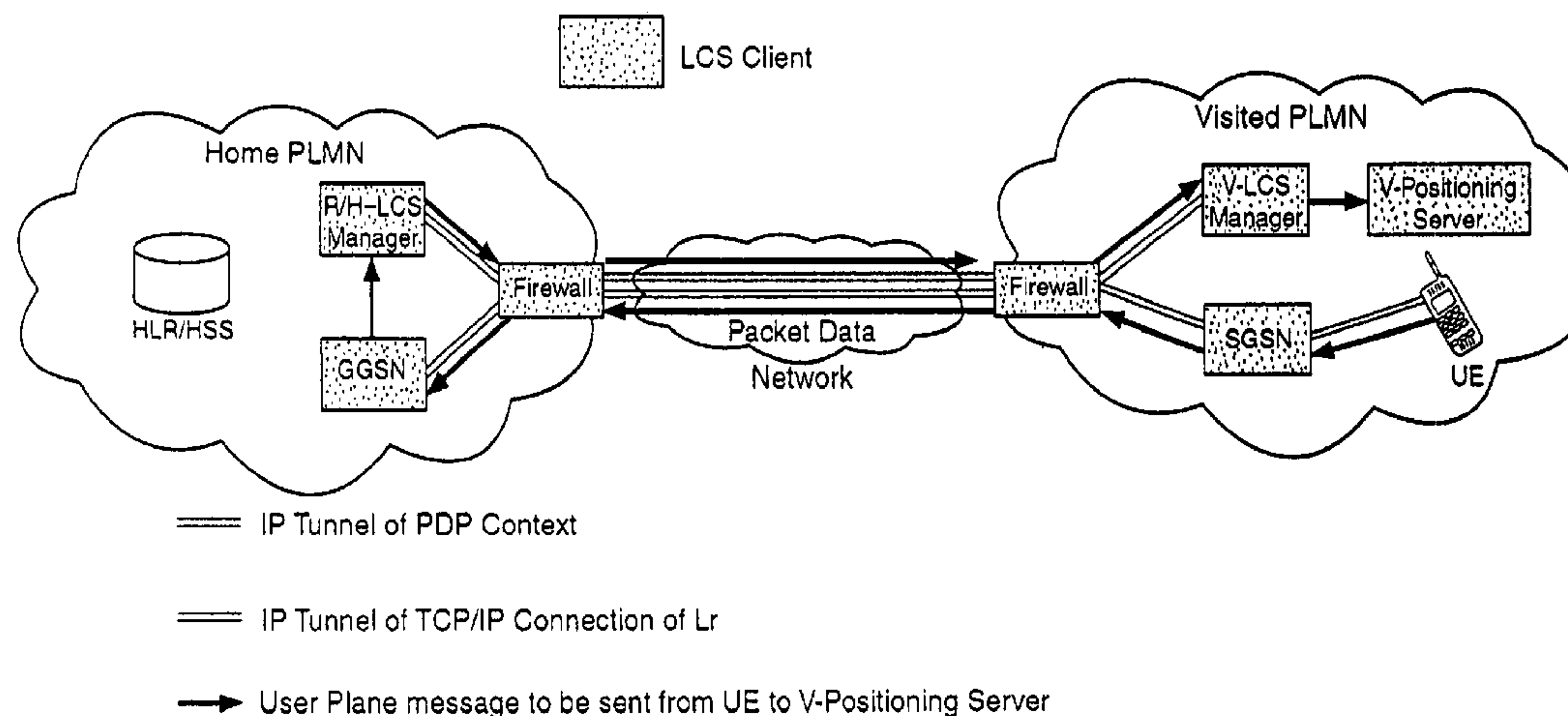
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(57) **ABSTRACT**

An improved User Plane location based service (LBS) archi-
tecture and message flow, enabling seamless User Plane loca-
tion based services even when a mobile or wireless device has
roamed among different carrier networks. The present inven-
tion overcomes constraints inherent in the current protocol for
roaming support defined by the Secure User Plane Location
Service specification. A location system is enabled to auto-
matically fall back to a message tunneling mechanism to
ensure the security of a communication path between the
location service system and the target wireless device, ensur-
ing that the communication path is uninterrupted as the wire-
less device travels.

15 Claims, 5 Drawing Sheets



(51)	Int. Cl.		5,530,655 A	6/1996	Lokhoff et al.
	<i>H04W 76/02</i>	(2009.01)	5,530,914 A	6/1996	McPheters
	<i>H04W 8/20</i>	(2009.01)	5,532,690 A	7/1996	Hertel
	<i>H04W 76/04</i>	(2009.01)	5,535,434 A	7/1996	Siddoway
	<i>H04W 4/12</i>	(2009.01)	5,539,398 A	7/1996	Haall
	<i>H04L 12/58</i>	(2006.01)	5,539,829 A	7/1996	Lokhoff et al.
	<i>H04L 29/06</i>	(2006.01)	5,543,776 A	8/1996	L'Esperance
	<i>H04W 12/08</i>	(2009.01)	5,552,772 A	9/1996	Janky
(56)	References Cited		5,555,286 A	9/1996	Tendler
	U.S. PATENT DOCUMENTS		5,568,119 A	10/1996	Schippler
			5,574,648 A	11/1996	Pilley
			5,579,372 A	11/1996	Angstrom
			5,588,009 A	12/1996	Will
			5,592,535 A	1/1997	Klotz
			5,604,486 A	2/1997	Lauro
			5,606,313 A	2/1997	Allen
			5,606,618 A	2/1997	Lokhoff et al.
			5,606,850 A	3/1997	Nakamura
			5,610,815 A	3/1997	Gudat
			5,614,890 A	3/1997	Fox
			5,615,116 A	3/1997	Gudat
			5,628,051 A	5/1997	Salin
			5,629,693 A	5/1997	Janky
			5,633,912 A	5/1997	Tsoi
			5,636,276 A	6/1997	Brugger
			5,661,755 A	8/1997	Van De Kerkhof et al.
			5,682,600 A	10/1997	Salin
			5,699,053 A	12/1997	Jonsson
			5,704,029 A	12/1997	Wright, Jr.
			5,717,688 A	2/1998	Belanger et al.
			5,721,781 A	2/1998	Deo
			5,740,534 A	4/1998	Ayerst
			5,761,618 A	6/1998	Lynch
			5,765,152 A	6/1998	Erickson
			5,767,795 A	6/1998	Schaphorst
			5,768,509 A	6/1998	Gunluk
			5,771,353 A	6/1998	Eggleston
			5,774,533 A	6/1998	Patel
			5,774,670 A	6/1998	Montully
			5,787,357 A	7/1998	Salin
			5,794,142 A	8/1998	Vantilla
			5,797,094 A	8/1998	Houde
			5,797,096 A	8/1998	Lupien
			5,802,492 A	9/1998	DeLorme
			5,806,000 A	9/1998	Vo
			5,809,415 A	9/1998	Rossmann
			5,812,087 A	9/1998	Krasner
			5,822,700 A	10/1998	Hult
			5,828,740 A	10/1998	Khue
			5,841,396 A	11/1998	Krasner
			5,857,201 A	1/1999	Wright, Jr. et al.
			5,864,667 A	1/1999	Barkan
			5,874,914 A	2/1999	Krasner
			5,896,369 A	4/1999	Warsta
			5,920,821 A	7/1999	Seaholtz
			5,922,074 A	7/1999	Richard et al.
			5,930,250 A	7/1999	Klok
			5,930,701 A	7/1999	Skog
			5,943,399 A	8/1999	Bannister
			5,945,944 A	8/1999	Krasner
			5,946,629 A	8/1999	Sawyer
			5,946,630 A	8/1999	Willars
			5,950,130 A	9/1999	Coursey
			5,953,398 A	9/1999	Hill
			5,960,362 A	9/1999	Grob
			5,974,054 A	10/1999	Couts
			5,978,685 A	11/1999	Lahai
			5,983,099 A	11/1999	Yao et al.
			5,987,323 A	11/1999	Huotari
			5,998,111 A	12/1999	Abe
			5,999,124 A	12/1999	Sheynblat
			6,032,051 A	2/2000	Hall
			6,035,025 A	3/2000	Hanson
			6,049,710 A	4/2000	Nilsson
			6,052,081 A	4/2000	Krasner
			6,058,300 A	5/2000	Hanson
			6,058,338 A	5/2000	Agashe et al.
			6,061,018 A	5/2000	Sheynblat
			6,061,346 A	5/2000	Nordman

(56)

References Cited

U.S. PATENT DOCUMENTS

6,064,336 A	5/2000	Krasner	6,477,150 B1	11/2002	Maggenti
6,064,875 A	5/2000	Morgan	6,504,491 B1	1/2003	Christians
6,070,067 A	5/2000	Nguyen	6,505,049 B1	1/2003	Dorenbosch
6,075,982 A	6/2000	Donovan	6,510,387 B2	1/2003	Fuchs et al.
6,081,229 A	6/2000	Soliman	6,512,922 B1	1/2003	Burg et al.
6,081,508 A	6/2000	West	6,512,930 B2	1/2003	Sandegren
6,085,320 A	7/2000	Kaliski, Jr.	6,515,623 B2	2/2003	Johnson
6,101,378 A	8/2000	Barabash	6,519,466 B2	2/2003	Pande et al.
6,104,931 A	8/2000	Havinis	6,522,682 B1	2/2003	Kohli et al.
6,122,503 A	9/2000	Daly	6,529,490 B1	3/2003	Oh
6,122,520 A	9/2000	Want	6,529,722 B1	3/2003	Heinrich
6,124,810 A	9/2000	Segal et al.	6,529,829 B2	3/2003	Turetzky et al.
6,128,664 A	10/2000	Yanagidate	6,531,982 B1	3/2003	White et al.
6,131,067 A	10/2000	Girerd	6,538,757 B1	3/2003	Sansone
6,133,874 A	10/2000	Krasner	6,539,200 B1	3/2003	Schiff
6,134,483 A	10/2000	Vayanos et al.	6,539,304 B1	3/2003	Chansarkar
6,148,197 A	11/2000	Bridges	6,542,464 B1	4/2003	Tekeda
6,148,198 A	11/2000	Anderson	6,542,734 B1	4/2003	Abrol et al.
6,149,353 A	11/2000	Nillson	6,542,743 B1	4/2003	Soliman
6,150,980 A	11/2000	Krasner	6,549,522 B1	4/2003	Flynn
6,169,891 B1	1/2001	Gorham	6,549,776 B1	4/2003	Joong
6,173,181 B1	1/2001	Losh	6,549,844 B1	4/2003	Egberts
6,178,505 B1	1/2001	Schneider	6,556,832 B1	4/2003	Soliman
6,178,506 B1	1/2001	Quick, Jr.	6,560,534 B2	5/2003	Abraham et al.
6,181,935 B1	1/2001	Gossman	6,570,530 B2	5/2003	Gaal et al.
6,181,939 B1	1/2001	Ahvenainen	6,571,095 B1	5/2003	Koodli
6,185,427 B1	2/2001	Krasner	6,574,558 B2	6/2003	Kohli
6,188,354 B1	2/2001	Soliman et al.	6,584,307 B1	6/2003	Antonucci
6,188,752 B1	2/2001	Lesley	6,584,552 B1	6/2003	Kuno
6,188,909 B1	2/2001	Alanara	6,594,500 B2	7/2003	Bender et al.
6,189,089 B1	2/2001	Walker et al.	6,597,311 B2	7/2003	Sheynblat et al.
6,198,431 B1	3/2001	Gibson	6,600,927 B2	7/2003	Hamilton
6,199,045 B1	3/2001	Giniger	6,606,495 B1	8/2003	Korpi et al.
6,199,113 B1	3/2001	Alegre	6,606,554 B2	8/2003	Edge
6,205,330 B1	3/2001	Winbladh	6,609,004 B1	8/2003	Morse et al.
6,208,290 B1	3/2001	Krasner	6,611,757 B2	8/2003	Brodie
6,208,854 B1	3/2001	Roberts	6,618,670 B1	9/2003	Chansarkar
6,215,441 B1	4/2001	Moeglein	6,621,452 B2	9/2003	Knockeart et al.
6,219,557 B1	4/2001	Havinis	6,628,233 B2	9/2003	Knockeart et al.
6,223,046 B1	4/2001	Hamill-Keays	6,633,255 B2	10/2003	Krasner
6,226,529 B1	5/2001	Bruno	6,640,184 B1	10/2003	Rabe
6,239,742 B1	5/2001	Krasner	6,650,901 B1	11/2003	Schuster
6,247,135 B1	6/2001	Feague	6,661,372 B1	12/2003	Girerd
6,249,680 B1	6/2001	Wax	6,665,539 B2	12/2003	Sih et al.
6,249,744 B1	6/2001	Morita	6,665,541 B1	12/2003	Krasner et al.
6,249,783 B1	6/2001	Crone et al.	6,671,620 B1	12/2003	Garin et al.
6,253,074 B1	6/2001	Carlsson	6,677,894 B2	1/2004	Sheynblat et al.
6,260,147 B1	7/2001	Quick, Jr.	6,678,357 B2	1/2004	Stumer
6,266,614 B1	7/2001	Alumbaugh	6,680,694 B1	1/2004	Knockeart et al.
6,275,692 B1	8/2001	Skog	6,680,695 B2	1/2004	Turetzky et al.
6,275,849 B1	8/2001	Ludwig	6,694,258 B2	2/2004	Johnson et al.
6,289,373 B1	9/2001	DeZonno	6,697,629 B1	2/2004	Grilli et al.
6,307,504 B1	10/2001	Sheynblat	6,701,144 B2	3/2004	Kirbas et al.
6,308,269 B2	10/2001	Proidl	6,703,971 B2	3/2004	Pande et al.
6,313,786 B1	11/2001	Sheynblat	6,703,972 B2	3/2004	van Diggelmen
6,317,594 B1	11/2001	Gossman	6,704,651 B2	3/2004	van Diggelmen
6,321,091 B1	11/2001	Holland	6,707,421 B1	3/2004	Drury et al.
6,321,250 B1	11/2001	Knape	6,714,793 B1	3/2004	Carey et al.
6,321,257 B1	11/2001	Kotola	6,718,174 B2	4/2004	Vayanos
6,324,542 B1	11/2001	Wright, Jr.	6,720,915 B2	4/2004	Sheynblat
6,327,473 B1	12/2001	Soliman et al.	6,721,578 B2	4/2004	Minear et al.
6,327,479 B1	12/2001	Mikkola	6,721,871 B2	4/2004	Pispanen
6,333,919 B2	12/2001	Gafney	6,724,342 B2	4/2004	Bloebaum et al.
6,360,093 B1	3/2002	Ross et al.	6,725,159 B2	4/2004	Krasner
6,367,019 B1	4/2002	Ansell	6,731,940 B1	5/2004	Nagendran
6,370,389 B1	4/2002	Isomursu	6,734,821 B2	5/2004	van Diggelen
6,377,209 B1	4/2002	Krasner	6,738,013 B2	5/2004	Orler
6,400,314 B1	6/2002	Krasner	6,738,800 B1	5/2004	Aquilon
6,400,958 B1	6/2002	Isomursu	6,741,842 B2	5/2004	Goldberg et al.
6,411,254 B1	6/2002	Moeglein	6,744,856 B2	6/2004	Karnik
6,421,002 B2	7/2002	Krasner	6,745,038 B2	6/2004	Callaway
6,433,734 B1	8/2002	Krasner	6,747,596 B2	6/2004	Orler
6,449,473 B1	9/2002	Raivisto	6,748,195 B1	6/2004	Phillips
6,449,476 B1	9/2002	Hutchison, IV	6,751,464 B1	6/2004	Burg et al.
6,456,852 B2	9/2002	Bar	6,756,938 B2	6/2004	Zhao et al.
			6,757,266 B1	6/2004	Hundscheidt
			6,757,544 B2	6/2004	Rangarajan et al.
			6,771,742 B2	8/2004	McCalmont
			6,772,340 B1	8/2004	Peinado

(56)

References Cited

U.S. PATENT DOCUMENTS

6,775,655 B1	8/2004	Peinado	7,103,018 B1	9/2006	Hansen	
6,775,802 B2	8/2004	Gaal	7,103,574 B1	9/2006	Peinado	
6,778,136 B2	8/2004	Gronemeyer	7,106,717 B2	9/2006	Rousseau	
6,778,885 B2	8/2004	Agashe et al.	7,136,838 B1	11/2006	Peinado	
6,781,963 B2	8/2004	Crockett	7,151,946 B2	12/2006	Maggenti	
6,788,249 B1	9/2004	Farmer et al.	7,184,418 B1	2/2007	Baba	
6,795,699 B1	9/2004	McCraw et al.	7,209,969 B2	4/2007	Lahti	
6,799,049 B1	9/2004	Zellner	7,218,940 B2	5/2007	Niemenmaa	
6,799,050 B1	9/2004	Krasner	7,221,959 B2	5/2007	Lindqvist	
6,801,159 B2	10/2004	Swope et al.	7,246,187 B1	7/2007	Ezra	
6,804,524 B1	10/2004	Vandermeijden	7,260,186 B2	8/2007	Zhu	
6,807,534 B1	10/2004	Erickson	7,321,773 B2	1/2008	Hines	
6,810,323 B1	10/2004	Bullock et al.	7,440,442 B2	10/2008	Grabelsky	
6,813,560 B2	11/2004	van Diggelen	7,522,581 B2	4/2009	Acharya	
6,816,111 B2	11/2004	Krasner	7,623,447 B1	11/2009	Faccin	
6,816,710 B2	11/2004	Krasner	7,702,081 B1	4/2010	Klesper	
6,816,719 B1	11/2004	Heinonen	7,895,263 B1	2/2011	Kirchmeier	
6,816,734 B2	11/2004	Wong et al.	RE42,927 E	11/2011	Want	
6,820,269 B2	11/2004	Baucke	2001/0046215 A1 *	11/2001	Kim	370/329
6,829,475 B1	12/2004	Lee et al.	2002/0037735 A1	3/2002	Maggenti	
6,832,373 B2	12/2004	O'Neill	2002/0052214 A1	5/2002	Maggenti	
6,839,020 B2	1/2005	Geier et al.	2002/0058515 A1	5/2002	Holler	
6,839,021 B2	1/2005	Sheynblat et al.	2002/0061760 A1	5/2002	Maggenti	
6,842,715 B1	1/2005	Gaal	2002/0069259 A1	6/2002	Kushwaha	
6,853,916 B2	2/2005	Fuchs et al.	2002/0085538 A1	7/2002	Leung	
6,856,282 B2	2/2005	Mauro et al.	2002/0086659 A1	7/2002	Lauper	
6,861,980 B1	3/2005	Rowitch et al.	2002/0102999 A1	8/2002	Maggenti	
6,865,171 B1	3/2005	Nilsson	2002/0112047 A1	8/2002	Kushwaha	
6,865,395 B2	3/2005	Riley	2002/0113797 A1	8/2002	Potter	
6,867,734 B2	3/2005	Voor	2002/0197991 A1	12/2002	Anvekar	
6,873,854 B2	3/2005	Crockett	2003/0009602 A1	1/2003	Jacobs	
6,885,940 B2	4/2005	Brodie et al.	2003/0016804 A1	1/2003	Sheha	
6,888,497 B2	5/2005	King et al.	2003/0037163 A1	2/2003	Kitada et al.	
6,888,932 B2	5/2005	Snip	2003/0065788 A1	4/2003	Salomaki	
6,895,238 B2	5/2005	Newell et al.	2003/0072318 A1 *	4/2003	Lam et al.	370/428
6,895,249 B2	5/2005	Gaal	2003/0078064 A1	4/2003	Chan	
6,900,758 B1	5/2005	Mann et al.	2003/0078886 A1	4/2003	Minear	
6,903,684 B1	6/2005	Simic et al.	2003/0081557 A1	5/2003	Mettala	
6,904,029 B2	6/2005	Fors et al.	2003/0101329 A1	5/2003	Lahti	
6,907,224 B2	6/2005	Younis	2003/0103484 A1	6/2003	Oommen et al.	
6,907,238 B2	6/2005	Leung	2003/0114148 A1	6/2003	Albertson	
6,912,395 B2	6/2005	Beres et al.	2003/0115328 A1	6/2003	Salminen	
6,912,545 B1	6/2005	Lundy	2003/0137961 A1	7/2003	Tsirtsis	
6,915,208 B2	7/2005	Garin et al.	2003/0153340 A1	8/2003	Crockett	
6,917,331 B2	7/2005	Gronemeyer	2003/0153341 A1	8/2003	Crockett	
6,930,634 B2	8/2005	Peng et al.	2003/0153342 A1	8/2003	Crockett	
6,937,187 B2	8/2005	van Diggelen	2003/0153343 A1	8/2003	Crockett	
6,937,597 B1	8/2005	Rosenberg	2003/0161298 A1	8/2003	Bergman	
6,937,872 B2	8/2005	Krasner	2003/0186709 A1	10/2003	Rhodes	
6,940,950 B2	9/2005	Dickinson	2003/0196105 A1	10/2003	Fineberg	
6,941,144 B2	9/2005	Stein	2003/0204640 A1	10/2003	Sahinoja	
6,944,540 B2	9/2005	King et al.	2003/0223381 A1	12/2003	Schrodens	
6,947,772 B2	9/2005	Minear et al.	2004/0002326 A1	1/2004	Maher	
6,950,058 B1	9/2005	Davis et al.	2004/0044623 A1	3/2004	Wake	
6,957,073 B2	10/2005	Bye	2004/0068724 A1	4/2004	Gardner	
6,961,019 B1	11/2005	McConnell et al.	2004/0093217 A1	5/2004	Yeh	
6,961,562 B2	11/2005	Ross	2004/0098497 A1	5/2004	Banet	
6,963,557 B2	11/2005	Knox	2004/0132465 A1	7/2004	Mattila	
6,965,754 B2	11/2005	King	2004/0146040 A1 *	7/2004	Phan-Anh et al.	370/349
6,965,767 B2	11/2005	Maggenti	2004/0203732 A1	10/2004	Brusilovsky	
6,968,195 B2	11/2005	Nowak	2004/0205151 A1	10/2004	Sprigg	
6,970,917 B1	11/2005	Kushwaha	2004/0229632 A1 *	11/2004	Flynn et al.	455/456.3
6,973,320 B2	12/2005	Brown et al.	2004/0242238 A1	12/2004	Wang	
6,975,266 B2	12/2005	Abraham et al.	2005/0021769 A1	1/2005	Kim	
6,978,453 B2	12/2005	Rao	2005/0028034 A1	2/2005	Gantman	
6,980,816 B2	12/2005	Rohles	2005/0031095 A1	2/2005	Pietrowicz	
6,996,720 B1	2/2006	DeMello	2005/0039178 A1	2/2005	Marolia	
6,999,782 B2	2/2006	Shaughnessy	2005/0041578 A1	2/2005	Huotari	
7,024,321 B1	4/2006	Deninger et al.	2005/0043037 A1	2/2005	Ioppe	
7,024,393 B1	4/2006	Peinado	2005/0043038 A1	2/2005	Maanoja	
7,047,411 B1	5/2006	DeMello	2005/0086467 A1	4/2005	Asokan	
7,065,351 B2	6/2006	Carter et al.	2005/0111630 A1	5/2005	Potorney	
7,065,507 B2	6/2006	Mohammed	2005/0112030 A1	5/2005	Gaus	
7,079,857 B2	7/2006	Maggenti	2005/0153706 A1	7/2005	Niemenmaa	
7,092,385 B2	8/2006	Gallant	2005/0190892 A1	9/2005	Dawson	
			2005/0201358 A1	9/2005	Nelson	
			2005/0201528 A1	9/2005	Meer	
			2005/0201529 A1	9/2005	Nelson	
			2005/0209995 A1	9/2005	Aksu	

(56)

References Cited

U.S. PATENT DOCUMENTS

2005/0259675 A1 11/2005 Tuohino et al.
2006/0053225 A1 3/2006 Poikselka
2006/0212558 A1 9/2006 Sahinoja
2006/0212562 A1 9/2006 Kushwaha
2006/0224752 A1 10/2006 Parekh
2006/0234639 A1 10/2006 Kushwaha
2006/0234698 A1 10/2006 Fok
2006/0258380 A1 11/2006 Liebowitz
2006/0274696 A1 12/2006 Krishnamurthi
2007/0004429 A1 1/2007 Edge
2007/0026854 A1 2/2007 Nath
2007/0030539 A1 2/2007 Nath
2007/0049288 A1 3/2007 Lamprecht
2007/0054676 A1 3/2007 Duan
2007/0060097 A1 3/2007 Edge
2007/0149166 A1 6/2007 Turcotte
2007/0201623 A1 8/2007 Hines
2007/0253429 A1 11/2007 James
2007/0254625 A1 11/2007 Edge
2007/0291733 A1 12/2007 Doran
2008/0045250 A1 2/2008 Hwang
2008/0162637 A1 7/2008 Adamczyk
2008/0176582 A1 7/2008 Ghai
2008/0200182 A1 8/2008 Shim
2009/0003535 A1 1/2009 Grabelsky
2009/0067417 A1 3/2009 Kalavade
2009/0097450 A1 4/2009 Wallis

2009/0128404 A1 5/2009 Martino
2010/0003976 A1 1/2010 Zhu
2010/0054220 A1 3/2010 Bischinger
2010/0067444 A1 3/2010 Faccin
2010/0167760 A1 7/2010 Kim
2010/0188992 A1 7/2010 Raleigh
2010/0198933 A1 8/2010 Smith
2010/0223222 A1 9/2010 Zhou
2013/0012232 A1 1/2013 Titus et al.

OTHER PUBLICATIONS

International Search Report received in PCT/US2011/001990 dated Apr. 24, 2012.

European Search Report from EPO in European Appl. No. 04812593.4 dated Dec. 12, 2013.

3rd Generation Partnership Project: Technical Specification Group Services and System Aspects; 3G Security; IP network Layer Security (Release 6), 3GPP TS 33.210 V6.3.0 Technical Specification, Sep. 1, 2003, pp. 1-21.

Kent et al., Security Architecture for the Internet Protocol, Network Working Group, Nov. 1998, pp. 1-67.

3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Functional Stage 2 Description of LCS, 3GPP TS 23.271 V6.5.0 Technical Specification, Sep. 1, 2003, pp. 1-108.

U.S. Appl. No. 09/539,495, filed Mar. 2000, Abrol.

* cited by examiner

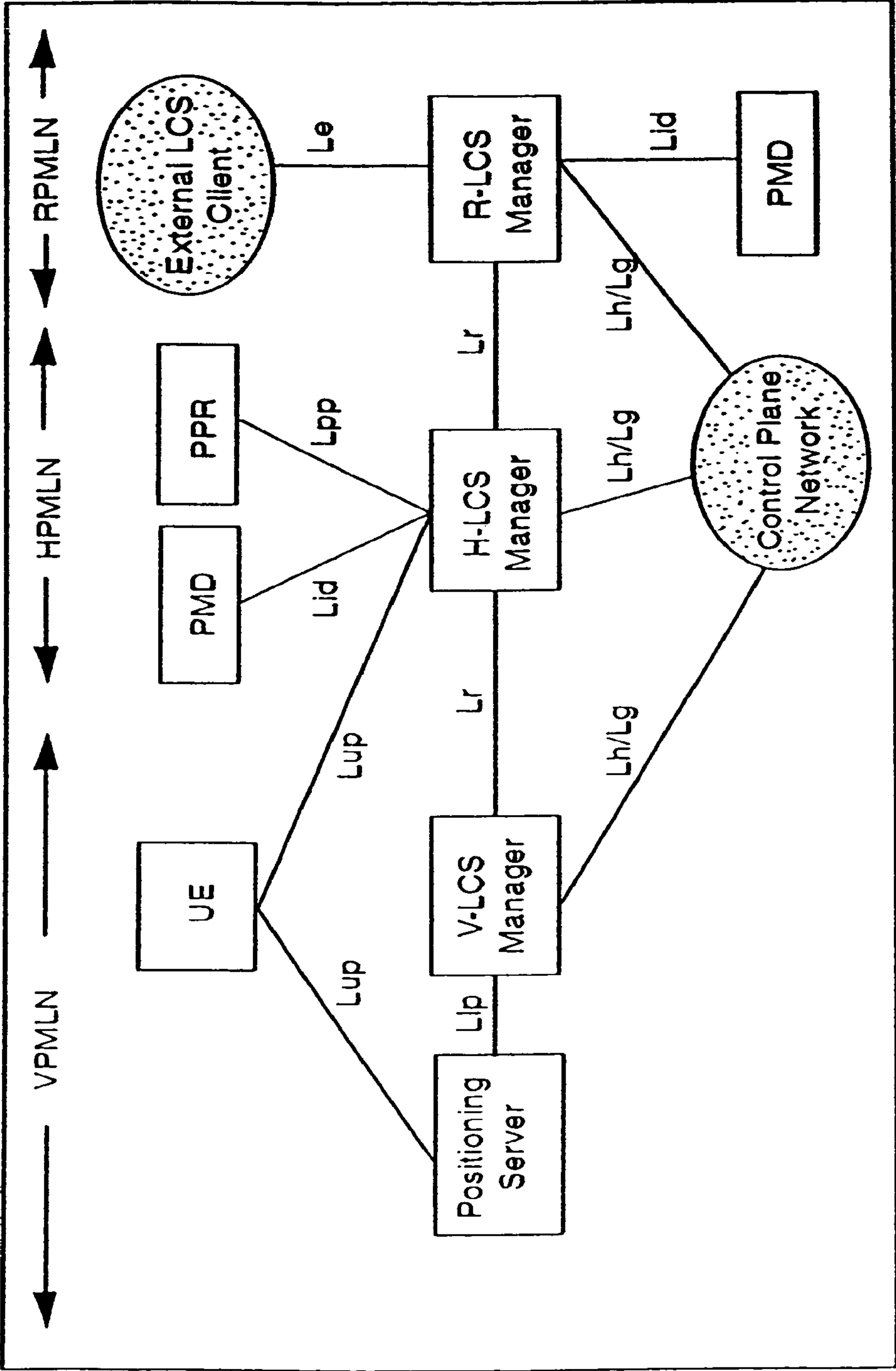


FIG. 1 (PRIOR ART)

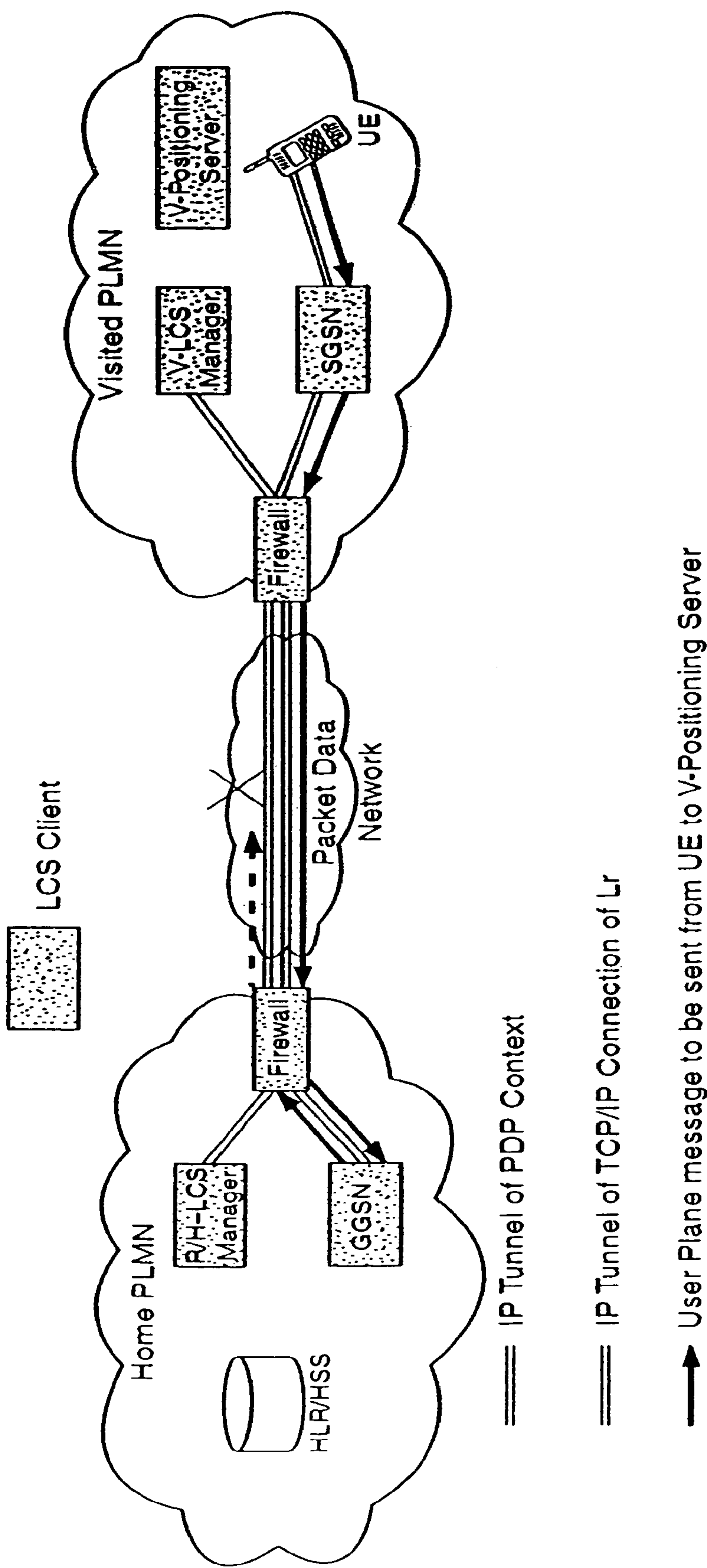


FIG. 2 (PRIOR ART)

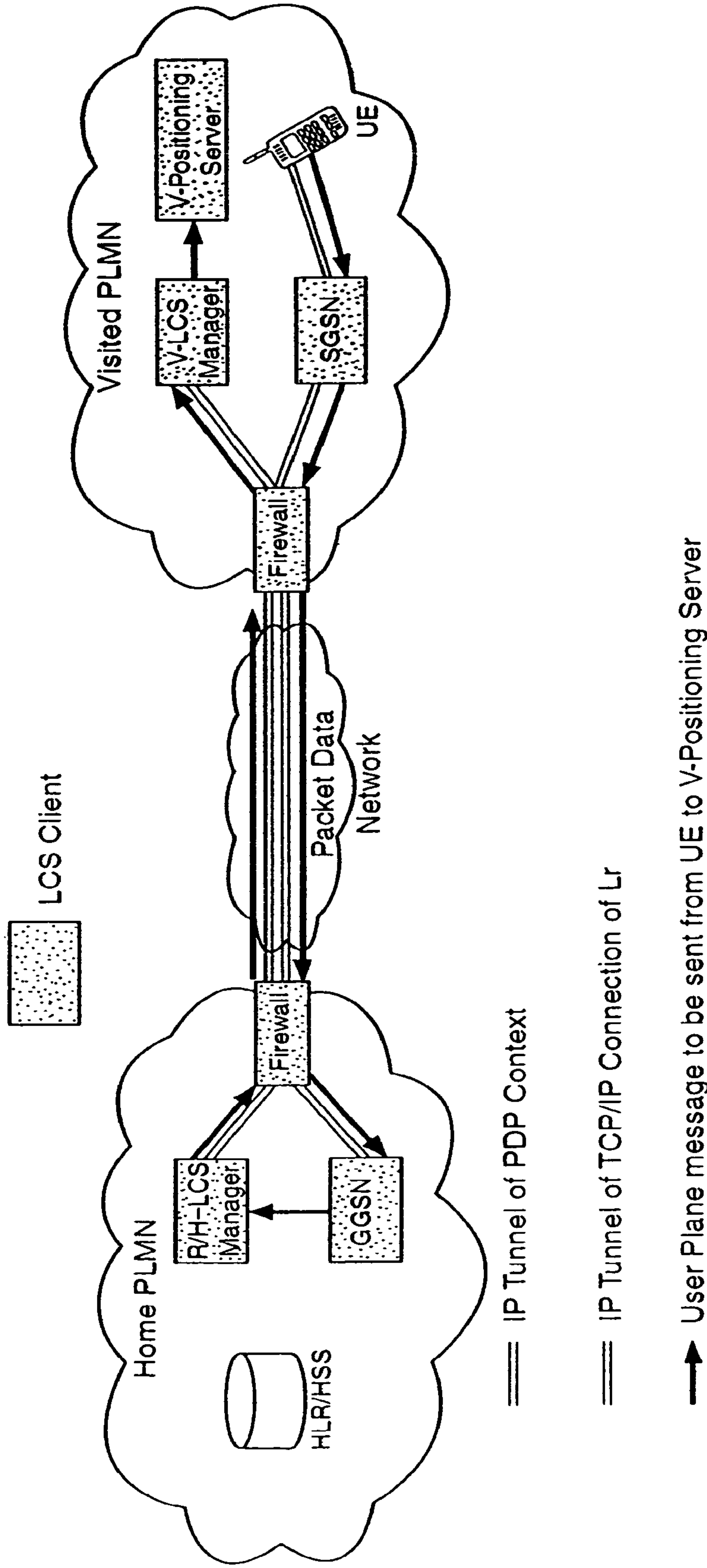


FIG. 3

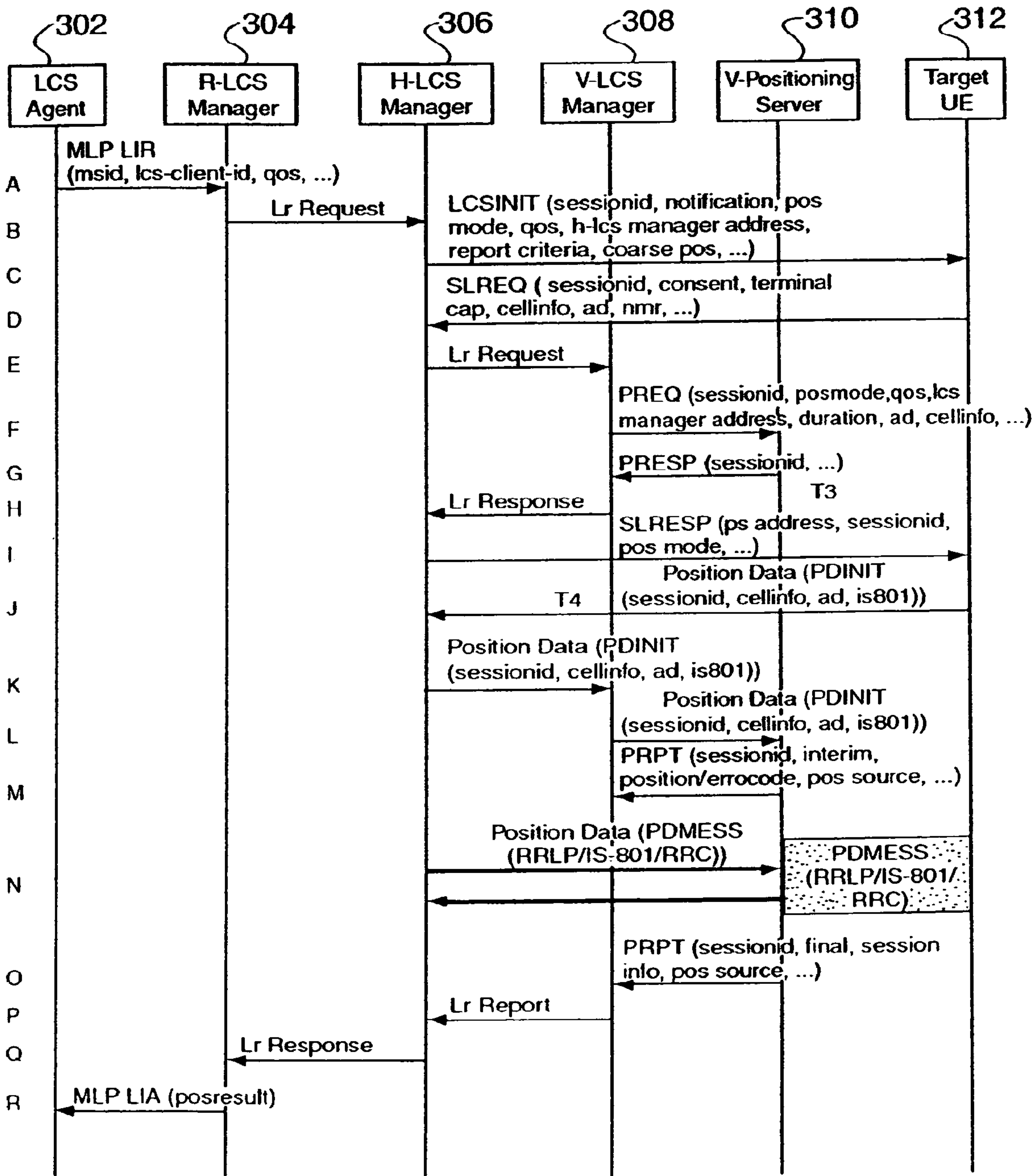


FIG. 4

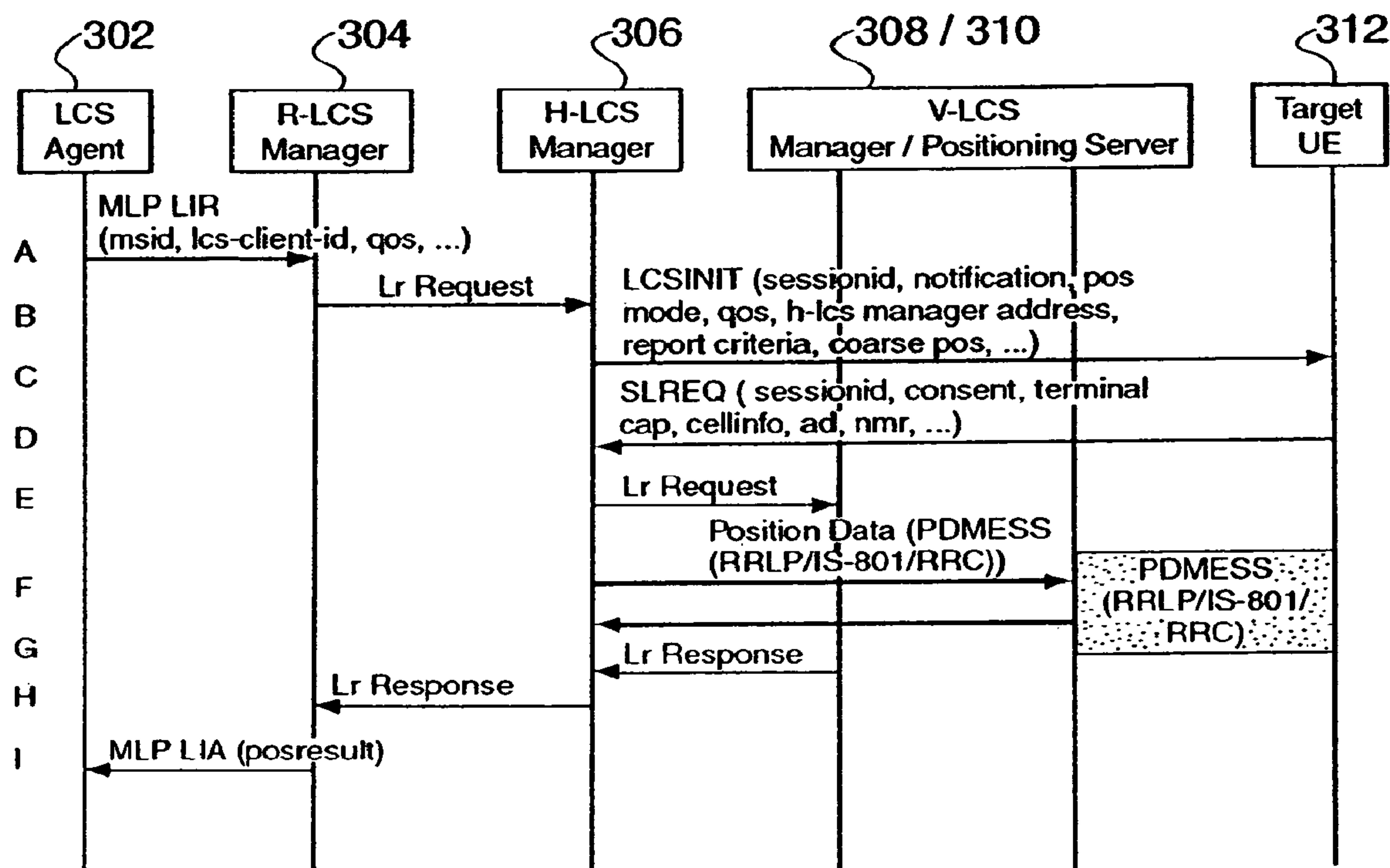


FIG. 5

USER PLANE LOCATION BASED SERVICE USING MESSAGE TUNNELING TO SUPPORT ROAMING

The present invention is a continuation of U.S. patent application Ser. No. 14/075,217, entitled "USER PLANE LOCATION BASED SERVICE USING MESSAGE TUNNELING TO SUPPORT ROAMING", filed on Nov. 8, 2013; which is a continuation of U.S. patent application Ser. No. 13/403,332, entitled "USER PLANE LOCATION BASED SERVICE USING MESSAGE TUNNELING TO SUPPORT ROAMING", filed on Feb. 23, 2012, now U.S. Pat. No. 8,626,160; which is a continuation of U.S. patent application Ser. No. 12/929,727, entitled "USER PLANE LOCATION BASED SERVICE USING MESSAGE TUNNELING TO SUPPORT ROAMING," filed on Feb. 11, 2011, now U.S. Pat. No. 8,126,458; which in turn is a continuation application of U.S. patent application Ser. No. 12/230,864, entitled "USER PLANE LOCATION BASED SERVICE USING MESSAGE TUNNELING TO SUPPORT ROAMING," filed on Sep. 5, 2008, now U.S. Pat. No. 7,890,102; which in turn is a continuation application of U.S. patent application Ser. No. 10/724,773, entitled "USER PLANE LOCATION BASED SERVICE USING MESSAGE TUNNELING TO SUPPORT ROAMING," filed on Dec. 2, 2003, now U.S. Pat. No. 7,424,293, the entirety of all of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to wireless and long distance carriers, Internet Service Providers (ISPs), and information content delivery services/providers and long distance carriers. More particularly, it relates to location services for the wireless industry.

2. Background of Related Art

It is desired to accurately locate the physical position of a wireless device (e.g., a wireless telephone) within a wireless network. There are currently two different types of architecture developed to accomplish a location based service (LSB): Control Plane location based services, and more recently User Plane location based services.

Older location based services utilize what is now called Control Plane location based services. A Control Plane location based service utilizes a management system to automate and build processes and perform inventory management. A Control Plane location based service utilizes control or signaling messages to determine the location of a particular wireless device.

A key difference between these two technologies is that a Control Plane solution uses a control channel to communicate with the wireless device, while a User Plane solution uses the subscriber's traffic channel itself (e.g. IP bearer or SMS) to communicate with the wireless device. A Control Plane solution requires software updates to almost all the existing network components and wireless devices, while a User Plane solution is recognized as a more feasible solution for carriers to provide location-based services.

The concept known as User Plane location based service makes use of the user's bearer channel itself, e.g., IP bearer or SMS, to establish the communications required for initiating a positioning procedure. User Plane location based services have been introduced as an alternative location service architecture as defined in standard organizations, e.g., 3GPP.

Thus, User Plane location based services utilize contents of the communications itself to locate the wireless device. User

Plane location based services focus on the TCP/IP capability of a wireless device such as a mobile telephone to generally bypass the carrier infrastructure and instead use, e.g., the Internet. There are significant advantages to the deployment of User Plane location based services, including an easier and more streamlined architecture than that of a Control Plane location based service. In this way, costly upgrades are avoided, and quick and relatively inexpensive deployment is possible using otherwise conventional system components.

In User Plane location based services, the inventors have noted that there is an issue related to location service procedure when the target mobile is roaming and IP bearer is used (IP bearer is the default bearer for User Plane location service solutions). Roaming refers to the physical movement of a wireless device among the territories covered by different wireless carriers.

In particular, based on conventional User Plane location service architecture, the target wireless device or mobile to be located must communicate with the Positioning Server (a.k.a. GMLC in 3GPP, MPC in 3GPP2) that is serving the cell where the wireless device camps. In this procedure, a PDP Context is established between the wireless device and the GGSN in the wireless device's Home Public Land Mobile Network (H-PLMN). The PDP Context is a communication channel established for the target wireless device to access IP networks, including an H-LCS Manager (a.k.a. H-GMLC in 3GPP, or H-MPC in 3GPP2), a Visited-LCS Manager (a.k.a. Visited-GMLC in 3GPP, or Visited MPC in 3GPP2), and/or a Positioning Server (a.k.a. SMLC in 3GPP, or PDE in 3GPP2).

However, the inventors herein realize that for security reasons, the IP networks of different PLMNs are separated with protective IP firewalls. Furthermore, inside a PLMN, the IP network is usually configured as a private network using private IP addresses. The IP connectivity to the Internet goes through a gateway router that provides NAT function. Yet, in currently defined User Plane location based services, a target wireless device must communicate with the positioning server in the Visited-PLMN via the GGSN in Home-PLMN, using the positioning server's private IP address provided by the Visited-LCS Manager. However, in a roaming scenario, it is realized that it is currently not permitted for a wireless device to communicate directly with a proper positioning server because of the various firewalls.

While User Plane location based solutions have been developed and deployed in a number of networks, support is not complete, especially when a GPRS IP bearer is used as the bearer. This invention introduces a methodology to resolve a key issue related to a roaming scenario for User Plane location based service solutions.

In conventional 3GPP network architectures, when a mobile initiates a packet data service session, called a PDP Context, the location SGNS will establish a connection to the GGSN indicated by an Access Point Name (APN) provided by the mobile. The GGSN identified by the APN usually resides in the Home Public Land Mobile Network (H-PLMN) of the mobile. So, in the roaming scenario, an IP bearer is established between the MS and the GGSN in the Home PLMN. Therefore, all the IP traffic to/from the mobile is tunneled to the Home PLMN.

With a Release 6 architecture of the 3GPP standard, a Gateway Mobile Location Center (GMLC) is able to communicate with other GMLCs that reside in different PLMNs, using an Lr interface. Thus, the Lr interface is allowed to go through the firewalls of PLMNs, attempting to provide adequate services in a roaming scenario.

In a typical Mobile Terminating (MT) location service in a roaming scenario, the mobile or wireless device must com-

communicate with the local positioning server of a User Plane location based service (sometimes referred to as "SMLC" using 3GPP standards terminology), to exchange location information and request assistance and a positioning calculation depending upon the particular positioning method being used.

However, during the MT location service procedure of a conventional User Plane location based service, a wireless device will be provided with the IP address of the local positioning server. As the inventors have appreciated, usually this IP address is a private IP address. Thus, while in theory full roaming support seems to be enabled, the inventors herein have appreciated that in reality the wireless device is not always able to reach this IP host from a private network (H-PLMN) because it is protected by firewalls.

There is the need to provide roaming support for a real-world subscriber utilizing a User Plane location based service in an existing GPRS network architecture.

SUMMARY OF THE INVENTION

In accordance with the principles of the present invention, message tunneling mechanism enables User Plane location service seamlessly supporting location based service even when the target subscriber is roaming in different networks.

In one aspect of the invention, a method of providing a User Plane location based service to a roaming wireless device comprises establishing a roaming interface between a home LCS manager of a home wireless carrier network and a visited LCS manager of a currently visited wireless carrier network. IP connectivity is directed over the Internet with the capability of being transmitted through a firewall in the home wireless carrier network and through a firewall in the visited wireless carrier network. A message tunneling mechanism is provided to provide an uninterrupted communication path between a location service system and a wireless device being located.

BRIEF DESCRIPTION OF THE DRAWINGS

Features and advantages of the present invention will become apparent to those skilled in the art from the following description with reference to the drawings, in which:

FIG. 1 shows an exemplary user plane location service architecture in accordance with an embodiment of the present invention.

FIG. 2 shows exemplary user plane location service signaling based on the user plane location service accordance shown in FIG. 1.

FIG. 3 shows exemplary enhanced user plane location service signaling using message-tunneling mechanism, based on the user plane location service accordance shown in FIG. 1.

FIG. 4 shows an exemplary message flow for message tunneling to support roaming in a User Plane location based service, in accordance with the principles of the present invention.

FIG. 5 shows an exemplary message flow for message tunneling to support roaming in a User Plane location based service, where Visited-LCS Manager and Visited-Positioning Server are integrated in one device, in accordance with the principles of the present invention.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

The present invention relates to the provision of an improved User Plane location based service (LBS) architec-

ture and message flow, enabling seamless User Plane location based services even when a mobile or wireless device has roamed among different carrier networks.

The present invention overcomes constraints inherent in the current protocol for roaming support defined by the Secure User Plane Location Service specification.

The inventive solution enables a location system to automatically fall back to a message tunneling mechanism to ensure the security of a communication path between the location service system and the target wireless device, ensuring that the communication path is uninterrupted as the wireless device travels.

FIG. 1 shows an exemplary user plane location service architecture in accordance with an embodiment of the present invention.

In particular, as shown in FIG. 1, a roaming interface (Lr) is established between LCS Managers (a.k.a. GMLCs in 3GPP, or MPCs in 3GPP2), which can direct IP connectivity through firewalls via the Internet. The inventive solution implements a message tunneling mechanism to provide end-to-end protocol connectivity via a Home-LCS Manager and/or a Visited-LCS Manager.

An important concept introduced by the present invention is the use of a messaging level tunneling via GMLCs using the Lr interface. With this method, a wireless device can communicate with the local positioning server, crossing PLMNs, to complete the requested User Plane positioning procedure.

FIG. 2 shows exemplary existing user plane location service signaling based on the user plane location service accordance shown in FIG. 1.

In particular, as shown in FIG. 2, when roaming UE needs to communicate with V-Positioning Server that resides in Visited PLMN, based on the procedure defined in User Plane LCS, it cannot even establish a TCP connection with the V-Positioning Server, although they are physically in the same network. Therefore, current User Plane architecture cannot support roaming scenarios for the mobile networks using private IP address assignments (which is very common in the industry due to the limited resource of IP addresses).

FIG. 3 shows exemplary enhanced user plane location service signaling using message-tunneling mechanism, based on the user plane location service accordance shown in FIG. 1.

In particular, FIG. 3 illustrates the concept of message tunneling for User Plane LCS service in roaming scenarios. In this case, UE sends a User Plane message, which should be sent to the V-Positioning Server, to the Home-LCS Manager instead. The Home-LCS Manager encapsulates the received message in a generic message and sends it to the V-LCS Manager. With existing 3GPP Release 6 architecture, a LCS Managers (a.k.a GMLC in 3GPP) is able to communicate with other LCS Managers (or GMLCs) that reside in different PLMNs, using Lr interface, i.e. Lr interface is allowed to go through the firewalls of PLMNs. The V-LCS Manager also uses message tunneling mechanism to pass the message from the UE to the V-Positioning Server, via local IP network connectivity.

FIG. 4 shows an exemplary message flow for message tunneling to support roaming in a User Plane location based service, in accordance with the principles of the present invention.

Step A

As shown in step A of FIG. 4, upon receiving a location request from a location service enabled application, the LCS Agent 302 may authenticate the application. If authentication is successful, the LCS Agent 302 issues an MLP Location

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request to the Requesting-LCS Manager **304**, with which LCS Agent is associated, for an immediate location fix.

Step B

The Requesting-LCS Manager **304** authenticates the LCS Agent **302**, and verifies that the LCS Agent **302** is authorized for the service it requests, based on the lcs-client-id received.

By examining the received msid of the target subscriber, the R-LCS Manager **304** can identify the relevant Home-LCS Manager **306** based, e.g., on roaming agreements, or using domain name service (DNS) lookup mechanism similar to IETF RFC 2916. The mechanisms used to identify the relevant Home-LCS Manager **306** are known to those of ordinary skill in the art.

The R-LCS Manager **304** then forwards the location request to the Home-LCS Manager **306** of the target subscriber, using an Lr interface.

Step C

Upon receipt of a location request, the Home-LCS Manager **306** applies subscriber Privacy against lcs-client-id, requestor-id, qos, etc. that are received in the request. This use case assumes privacy check success. If the LCS Manager **304** did not authorize the application, step N will be returned with the applicable MLP return code.

The H-LCS Manager **306** then initiates the location processing with the user equipment (UE) **312** using a suitable LCS INIT message, e.g., a wireless application protocol (WAP) PUSH, or a short messaging system (SMS) Trigger, and starts a timer T1.

The H-LCS Manager **306** can optionally provide UE coarse position information to the UE at this time if the H-LCS Manager **306** has knowledge of the coarse position.

If the result of the privacy check in Step B indicates that notification or verification to the target subscriber is needed, the H-LCS Manager **306** may also include a notification element in the LCS INIT message.

Step D

If Notification/Verification is required, UE popup text may be used to notify the subscriber who is requesting his/her location info, e.g., lcs-client-id, requestor-id, request-type, etc. Optionally, the subscriber may be allowed to either grant the location request or deny the location request.

If the target subscriber grants the location request, the UE **312** starts the positioning procedure by retrieving the current serving cell information, TA, NMR, and mobile device capabilities. The UE **312** then initiates a location session with the H-LCS Manager **306** using Start Location Request (SLREQ), with cell info and optional AD, TA and NMR if the UE needs to obtain assistance data, and/or TA and NMR are available. Optionally, the UE **312** also indicates whether the target subscriber has been granted access when verification is required in the LCS INIT message.

If the target subscriber denies the location request, the UE **312** initiates a location response to the H-LCS Manager **306** including indication of the denial.

When the H-LCS Manager **306** receives the SLREQ message from the target subscriber for the pending transaction, it stops the timer T1.

Step E

If the target subscriber has denied the location request in Step D, Step L will be returned with the applicable MLP return code. In this case, Steps E to K are skipped. Otherwise, with the cell information from the target UE **312** (or via another mechanism), the H-LCS Manager **306** can determine that the target UE **312** is roaming. Based on a relevant roaming agreement, or using a DNS lookup mechanism similar to IETF RFC 2916, the H-LCS Manager **306** can identify the Visited-LCS Manager **308**, and initiates an Lr request to the

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Visited-LCS Manager **308**, with an indicator that message tunneling mechanism will be used for this transition.

Step F

When receiving the Lr request, the Visited-LCS Manager **308** initiates a Position Request (PREQ), with optional cellinfo, NMR, device cap, etc., to the Positioning Server **310** that serves the area where target UE **312** currently is located.

Step G

The Positioning Server **310** sends a Position Response (PRESP) back to the V-LCS Manager **308**, and confirms that the Positioning Server **310** is ready to process the location request identified by sessionid.

Step H

Upon receipt of the Position Response message, the V-LCS Manager **308** sends an Lr Response message to the H-LCS Manager **306**. The Lr Response message may include, e.g., the IP address (URL) of the Positioning Server **310**.

Step I

Upon receiving the confirmation of the PRESP message from the serving Positioning Server **310**, the H-LCS Manager **306** sends a Start Location Response (SLRESP) message with the address of the H-LCS Manager **306** instead of V-Positioning Server for non-roaming scenario, if direct communication between the serving Positioning Server **310** and the target UE **312** is required, and an optional posmode to the target UE **312**.

Note, importantly, that the provided address of the serving Positioning Server **310** may be a private IP address in the roaming scenario.

Step J

Upon detection of roaming for the relevant UE **312**, the target UE **312** initiates position determination, e.g., Position Determination Initiation (PDINIT), and sessionid, to the H-LCS Manager **306**. The PDINIT message optionally contains additional information, e.g., cell id, ad, and/or IS-801 PDU.

Step K

When receiving the message, the H-LCS Manager **306** forwards the PDINIT message inside a Position Data message corresponding to the sessionid to the V-LCS Manager **308** via the relevant Lr connection.

Step L

The V-LCS Manager **308** forwards the received Position Data message to the serving Positioning Server **310**.

Step M

The Positioning Server **310** and the target UE **312** start a precise positioning procedure by exchanging Position Determination Messaging (PDMESS) messages encapsulated by Position Data as illustrated in Steps J, K and L, via the H-LCS Manager **306** and the V-LCS Manager **308**.

Importantly, the positioning procedure itself may be, e.g., an RRLP, IS-801, or RRC based transaction. However, the positioning procedure (e.g., RRLP, IS-801 or RRC) protocol is tunneled in PDMESS messages, which are tunneled by generic Position Data messages that are transported between H-LCS Manager and V-LCS Manager.

Step N

The Positioning Server **310** may send a Position Report (PRPT) to the R/H/V-LCS Managers **304**, **306**, **308** with the determined location information from the target UE **312**.

Steps O, P

Upon receiving the required position estimates from the Position Report (PRPT), the Visited-LCS Manager **308** forwards the location estimate to the Home-LCS Manager **306** using an Lr response message.

Step Q

The Home-LCS Manager **306** forwards the location estimate to the Requesting-LCS Manager **304** if the location estimate is allowed by the privacy settings of the target subscriber.

Step R

Finally, the Requesting-LCS Manager **304** sends an MLP SLIA message with location estimates back to the LCS Agent **302**.

FIG. 5 shows an exemplary message flow for message tunneling to support roaming in a User Plane location based service, where Visited-LCS Manager and Visited-Positioning Server are integrated in one device, in accordance with the principles of the present invention.

Step A

As shown in step A of FIG. 4, upon receiving a location request from a location service enabled application, the LCS Agent **302** may authenticate the application. If authentication is successful, the LCS Agent **302** issues an MLP Location request to the Requesting-LCS Manager **304**, with which LCS Agent is associated, for an immediate location fix.

Step B

The Requesting-LCS Manager **304** authenticates the LCS Agent **302**, and verifies that the LCS Agent **302** is authorized for the service it requests, based on the lcs-client-id received.

By examining the received msid of the target subscriber, the R-LCS Manager **304** can identify the relevant Home-LCS Manager **306** based, e.g., on roaming agreements, or using domain name service (DNS) lookup mechanism similar to IETF RFC 2916. The mechanisms used to identify the relevant Home-LCS Manager **306** are known to those of ordinary skill in the art.

The R-LCS Manager **304** then forwards the location request to the Home-LCS Manager **306** of the target subscriber, using an Lr interface.

Step C

Upon receipt of a location request, the Home-LCS Manager **306** applies subscriber Privacy against lcs-client-id, requestor-id, qos, etc. that are received in the request. This use case assumes privacy check success. If the LCS Manager **304** did not authorize the application, step N will be returned with the applicable MLP return code.

The H-LCS Manager **306** then initiates the location processing with the user equipment (UE) **312** using a suitable LCS INIT message, e.g., a wireless application protocol (WAP) PUSH, or a short messaging system (SMS) Trigger, and starts a timer T1.

The H-LCS Manager **306** can optionally provide UE coarse position information to the UE at this time if the H-LCS Manager **306** has knowledge of the coarse position.

If the result of the privacy check in Step B indicates that notification or verification to the target subscriber is needed, the H-LCS Manager **306** may also include a notification element in the LCS INIT message.

Step D

If Notification/Verification is required, UE popup text may be used to notify the subscriber who is requesting his/her location info, e.g., lcs-client-id, requestor-id, request-type, etc. Optionally, the subscriber may be allowed to either grant the location request or deny the location request.

If the target subscriber grants the location request, the UE **312** starts the positioning procedure by retrieving the current serving cell information, TA, NMR, and mobile device capabilities. The UE **312** then initiates a location session with the H-LCS Manager **306** using Start Location Request (SLREQ), with cell info and optional AD, TA and NMR if the UE needs to obtain assistance data, and/or TA and NMR are available.

Optionally, the UE **312** also indicates whether the target subscriber has been granted access when verification is required in the LCS INIT message.

If the target subscriber denies the location request, the UE **312** initiates a location response to the H-LCS Manager **306** including indication of the denial.

When the H-LCS Manager **306** receives the SLREQ message from the target subscriber for the pending transaction, it stops the timer T1.

Step E

If the target subscriber has denied the location request in Step D, Step L will be returned with the applicable MLP return code. In this case, Steps E to K are skipped. Otherwise, with the cell information from the target UE **312** (or via another mechanism), the H-LCS Manager **306** can determine that the target UE **312** is roaming. Based on a relevant roaming agreement, or using a DNS lookup mechanism similar to IETF RFC 2916, the H-LCS Manager **306** can identify the Visited-LCS Manager **308**, and initiates an Lr request to the Visited-LCS Manager **308**, with an indicator that message tunneling mechanism will be used for this transition.

Step F

The Positioning Server **310** and the target UE **312** start a precise positioning procedure by exchanging Position Determination Messaging (PDMESS) messages encapsulated by Position Data messages, via the H-LCS Manager **306** and the V-LCS Manager **308**.

Importantly, the positioning procedure itself may be, e.g., an RRLP, IS-801, or RRC based transaction. However, the positioning procedure (e.g., RRLP, IS-801 or RRC) protocol is tunneled in PDMESS messages, which are tunneled by generic Position Data messages that are transported between H-LCS Manager and V-LCS Manager.

Steps G

Upon receiving the required position estimates in Step F, the Visited-LCS Manager **308** forwards the location estimate to the Home-LCS Manager **306** using an Lr response message.

Step H

The Home-LCS Manager **306** forwards the location estimate to the Requesting-LCS Manager **304** if the location estimate is allowed by the privacy settings of the target subscriber.

Step I

Finally, the Requesting-LCS Manager **304** sends an MLP SLIA message with location estimates back to the LCS Agent **302**.

While the invention has been described with reference to the exemplary embodiments thereof, those skilled in the art will be able to make various modifications to the described embodiments of the invention without departing from the true spirit and scope of the invention.

What is claimed is:

1. A method of providing user plane location services using message tunneling to support roaming, comprising:
 - establishing a user plane roaming communication over a roaming interface (Lr) between a roaming wireless device (MT) and a visited location server (V-LCS) that serves a geographic area where said roaming wireless device is currently, via an intermediary home location server (H-LCS), said user plane roaming communication being tunneled in a Position Data message (PDMESS), wherein said user plane roaming communication includes an indicator that message tunneling is being used; and
 - providing an IP address of said serving positioning server to said roaming wireless device.

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2. The method of providing user plane location services using message tunneling to support roaming according to claim 1, wherein said user plane roaming communication comprises:

an Internet Protocol (IP) packetized message.

3. The method of providing user plane location services using message tunneling to support roaming according to claim 1, wherein said user plane roaming communication comprises:

a short messaging system (SMS) message.

4. The method of providing user plane location services using message tunneling to support roaming according to claim 1, wherein said user plane roaming communication comprises:

a text message.

5. The method of providing user plane location services using message tunneling to support roaming according to claim 1, further comprising:

passing said user plane roaming communication through a firewall protecting said visited location server (V-LCS).

6. The method of providing user plane location services using message tunneling to support roaming according to claim 1, wherein said user plane roaming communication comprises:

an Lr request.

7. The method of providing user plane location services using message tunneling to support roaming according to claim 1, further comprising:

transmitting, from said intermediary home location server (H-LCS) to said visited location server (V-LCS), a Position Data INIT (PDINIT) message inside said Position Data Message (PDMESS) corresponding to a sessionid.

8. The method of providing user plane location services using message tunneling to support roaming according to claim 7, wherein:

said PDINIT message is transmitted via a relevant roaming interface (Lr).

9. A home network location server to provide user plane location services using message tunneling to support roaming, comprising:

a roaming interface to establish a user plane roaming communication between a roaming wireless device (MT) and a visited positioning server that serves a geographic area where said roaming wireless device is currently, via

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an intermediary home positioning server, said user plane roaming communication being tunneled in a Position Data message (PDMESS), wherein said user plane roaming communication includes an indicator that message tunneling is being used; and

a home location services manager (H-LCS), associated with said intermediary home positioning server associated with said roaming wireless device, to obtain an IP address of said visited positioning server, and to transmit said IP address of said visited positioning server to said roaming wireless device.

10. A home network location server to provide user plane location services using message tunneling to support roaming according to claim 9, wherein:

said IP address is a private IP address.

11. A home network location server to provide user plane location services using message tunneling to support roaming according to claim 9, wherein:

said roaming interface passes through a firewall associated with said visited positioning server.

12. A home network location server to provide user plane location services using message tunneling to support roaming according to claim 9, wherein said user plane roaming communication comprises:

a short messaging system (SMS) message.

13. A home network location server to provide user plane location services using message tunneling to support roaming according to claim 9, wherein said user plane roaming communication comprises:

a text message.

14. A home network location server to provide user plane location services using message tunneling to support roaming according to claim 9, wherein said user plane roaming communication comprises:

an Lr request.

15. A home network location server to provide user plane location services using message tunneling to support roaming according to claim 9, wherein:

said intermediary home positioning server transmits a PDINIT message inside said Position Data message corresponding to a sessionid, to said visited positioning server.

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