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Baum

(54) IP BASED SECURITY APPLICATIONS USING LOCATION, PORT AND/OR DEVICE IDENTIFIER INFORMATION

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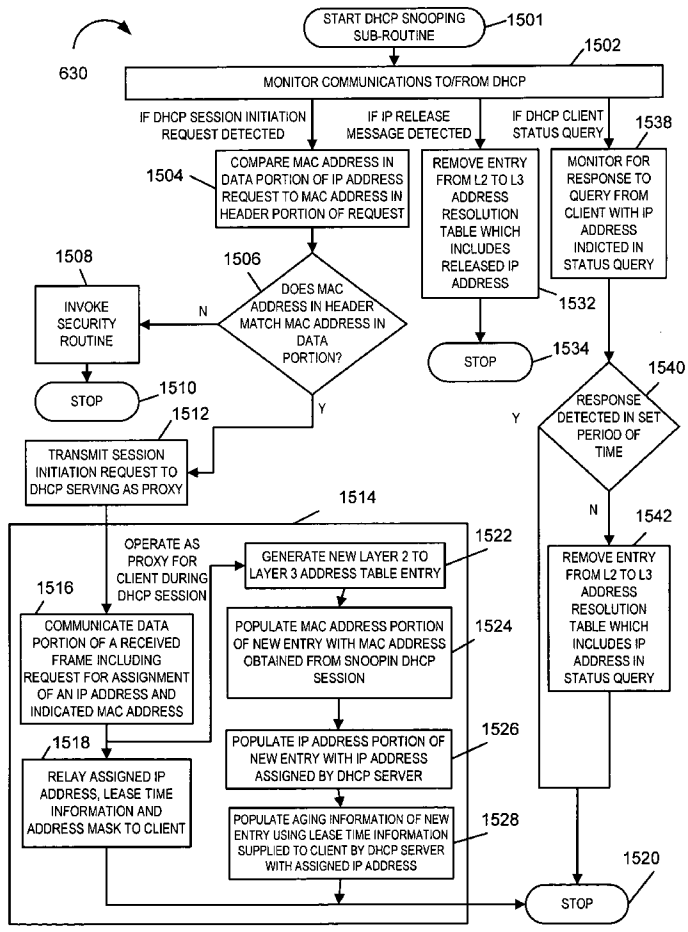
(52) **U.S. Cl.** **713/201**; 709/224

(57) **ABSTRACT**

Methods and apparatus for determining, in a reliable manner, a port, physical location and/or device identifier, such as a MAC address, associated with a device using an IP address and for using such information, e.g., to support one or more security applications is described. Supported security applications include restricting access to services based on the location of a device seeking access to a service, determining the location of stolen devices, and verifying the location of the source of a message or other IP signal, e.g., to determine if a prisoner is contacting a monitoring service from a predetermined location.



FreeWheel, Ex. 1157

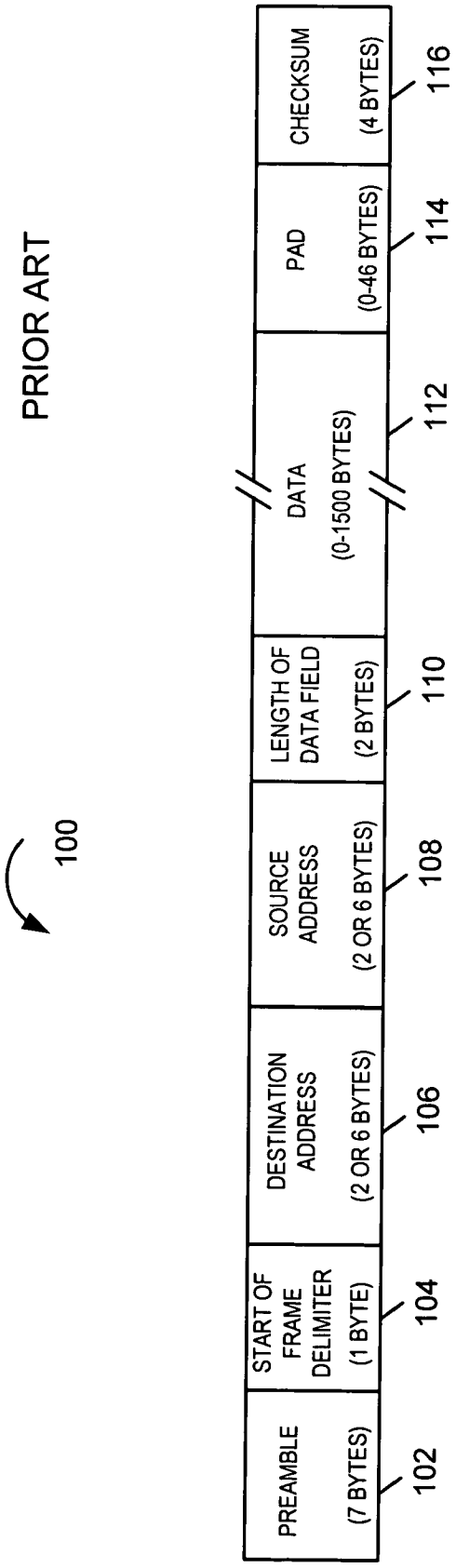

PRIOR ART
100
PREAMBLE
(7 BYTES)
102
START OF FRAME DELIMITER
(1 BYTE)
104
DESTINATION ADDRESS
(2 OR 6 BYTES)
106
SOURCE ADDRESS
(2 OR 6 BYTES)
108
LENGTH OF DATA FIELD
(2 BYTES)
110
DATA
(0-1500 BYTES)
112
PAD
(0-46 BYTES)
114
CHECKSUM
(4 BYTES)
116

FIGURE 1

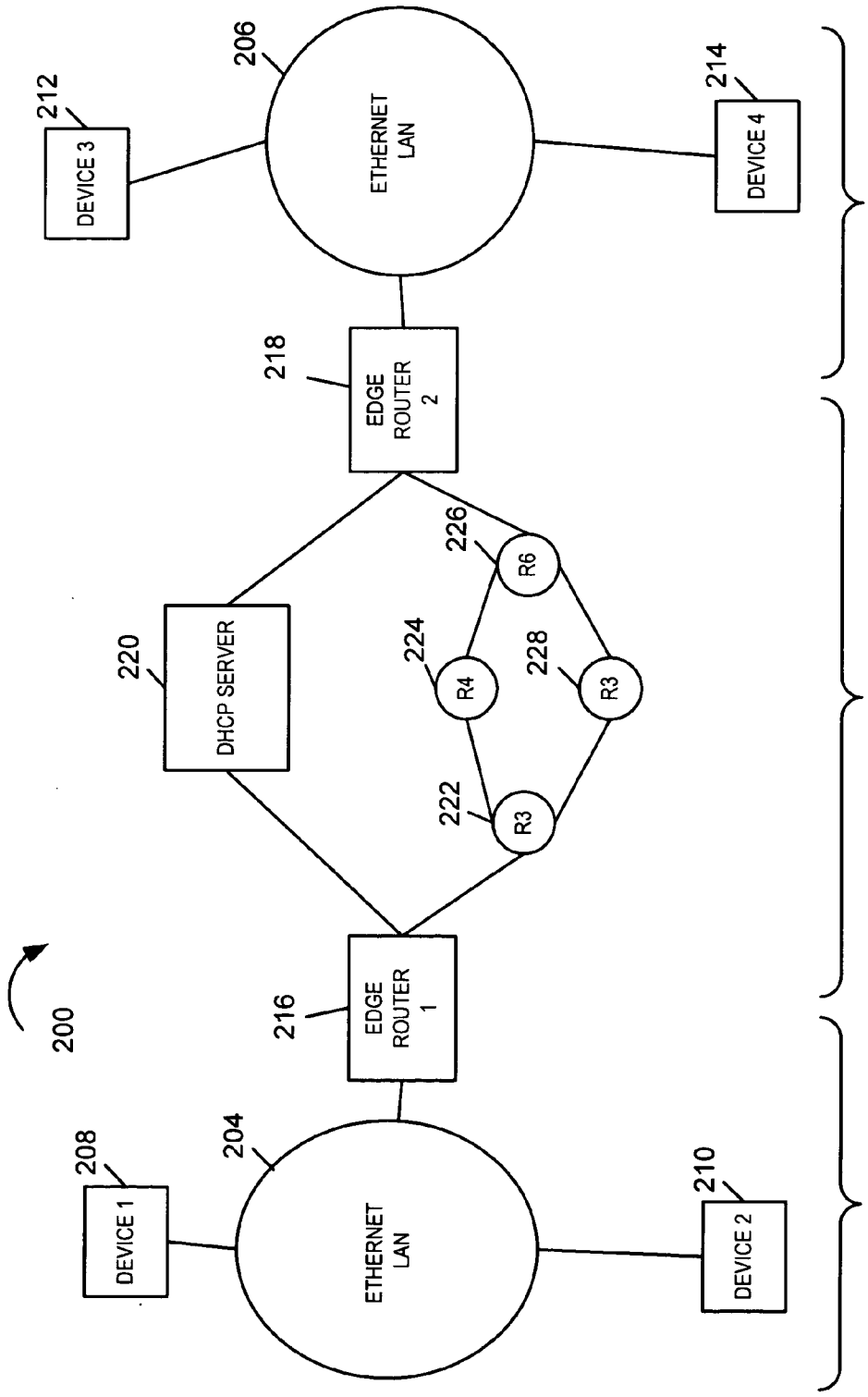

200
DEVICE 1
208
ETHERNET LAN
204
EDGE ROUTER 1
216
DHCP SERVER
220
R3
222
R4
224
R6
226
R3
228
EDGE ROUTER 2
218
DEVICE 2
210
201
205
DEVICE 3
212
ETHERNET LAN
206
DEVICE 4
214
203
PRIOR ART

FIGURE 2

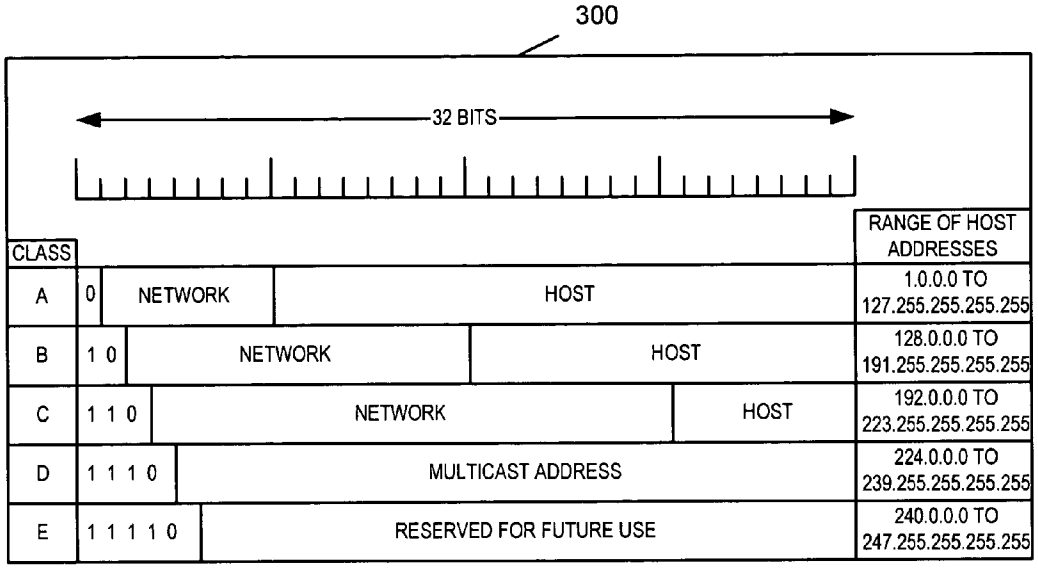


FIGURE 3

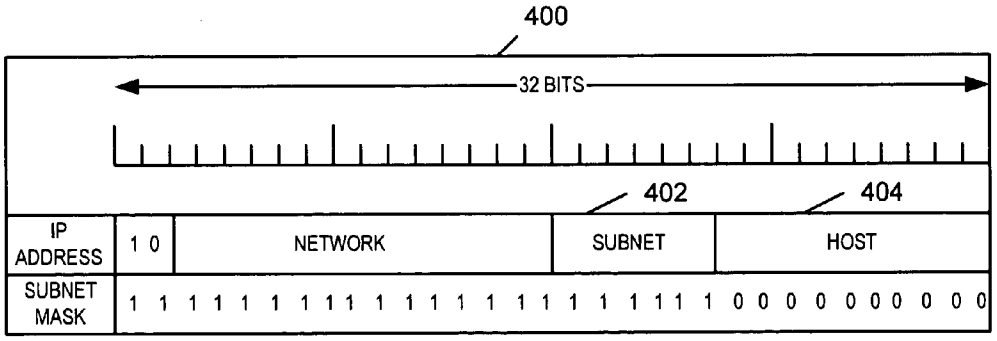


FIGURE 4

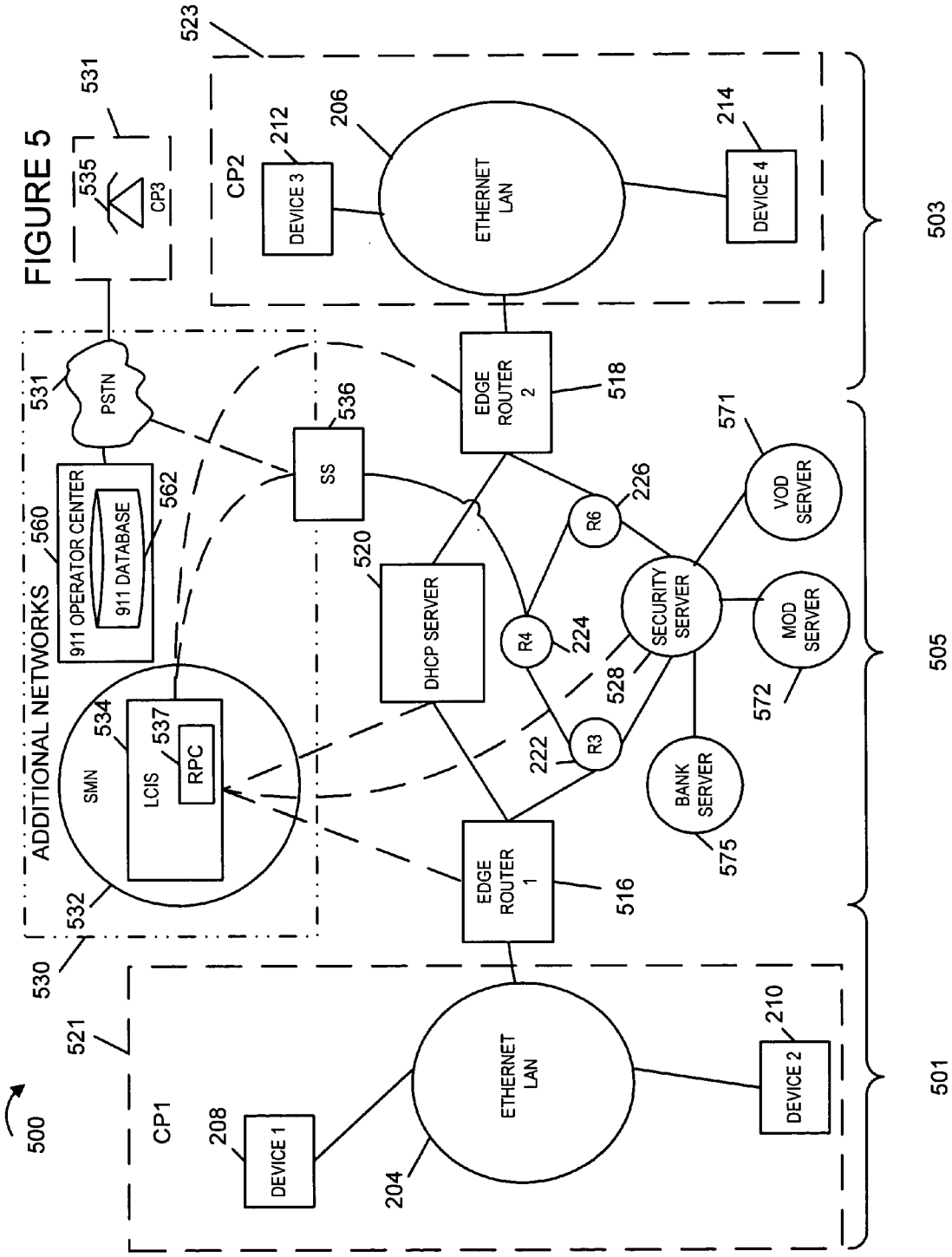


FIGURE 5
500
ADDITIONAL NETWORKS
530
531
PSTN
535
CP3
531
560
911 OPERATOR CENTER
911 DATABASE
562
SMN
532
534
LCIS
537
RPC
536
SS
520
DHCP SERVER
523
CP2
DEVICE 3
212
206
ETHERNET LAN
DEVICE 4
214
503
EDGE ROUTER 2
518
R6
226
R4
224
R3
222
SECURITY SERVER
528
571
VOD SERVER
MOD SERVER
572
BANK SERVER
575
505
EDGE ROUTER 1
516
521
CP1
DEVICE 1
208
204
ETHERNET LAN
DEVICE 2
210
501

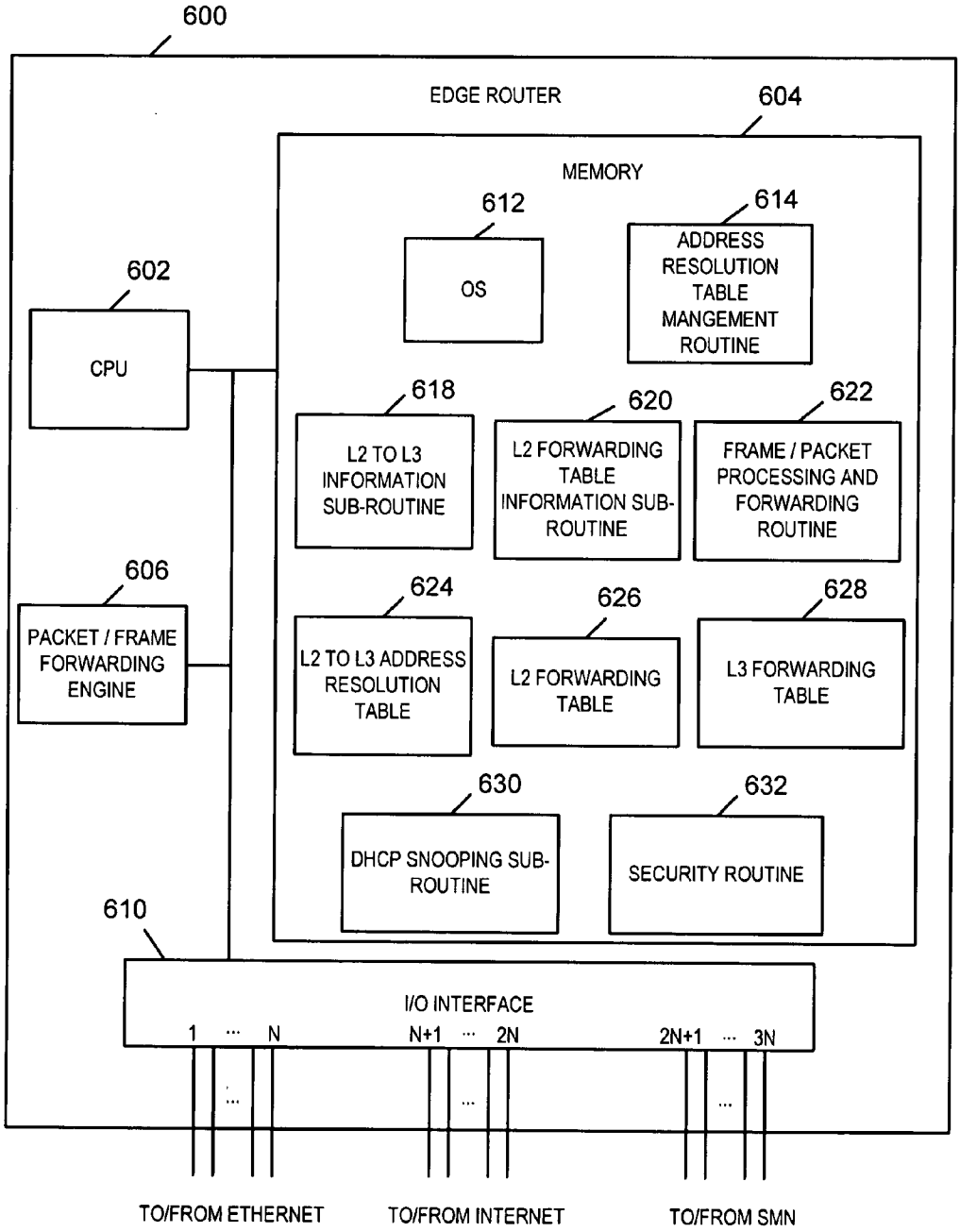

600
EDGE ROUTER
604
MEMORY
612
OS
614
ADDRESS RESOLUTION TABLE MANGEMENT ROUTINE
602
CPU
618
L2 TO L3 INFORMATION SUB-ROUTINE
620
L2 FORWARDING TABLE INFORMATION SUB-ROUTINE
622
FRAME / PACKET PROCESSING AND FORWARDING ROUTINE
606
PACKET / FRAME FORWARDING ENGINE
624
L2 TO L3 ADDRESS RESOLUTION TABLE
626
L2 FORWARDING TABLE
628
L3 FORWARDING TABLE
630
DHCP SNOOPING SUB-ROUTINE
632
SECURITY ROUTINE
610
I/O INTERFACE
1 ... N
N+1 ... 2N
2N+1 ... 3N
TO/FROM ETHERNET
TO/FROM INTERNET
TO/FROM SMN

FIGURE 6

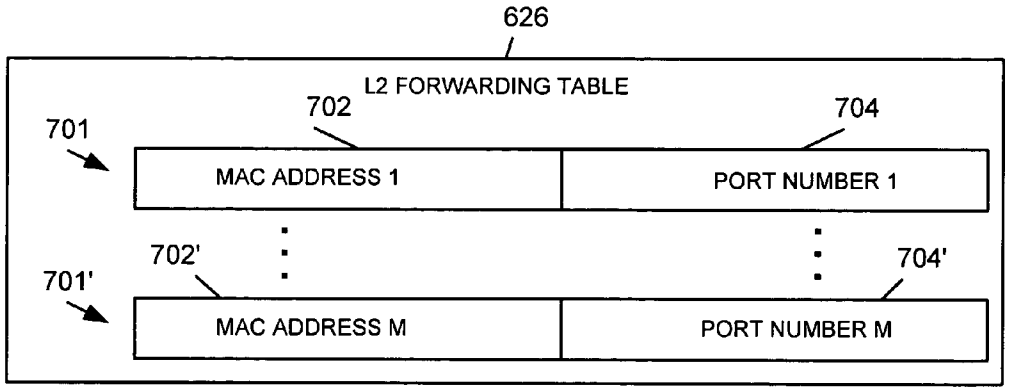


FIGURE 7

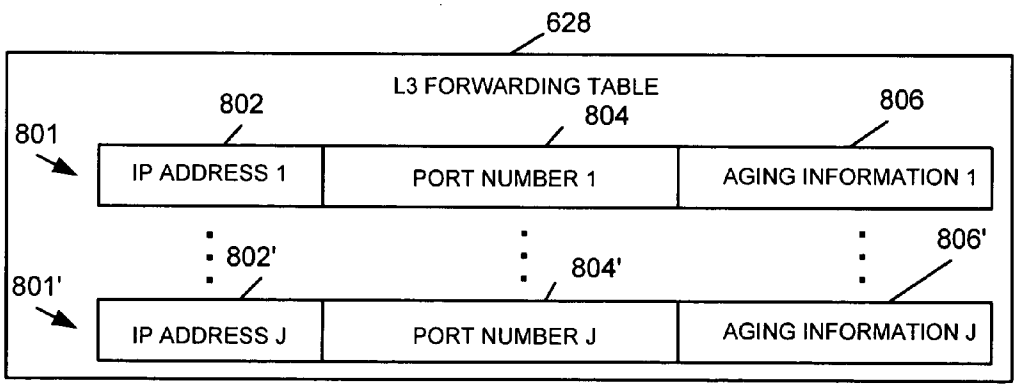


FIGURE 8

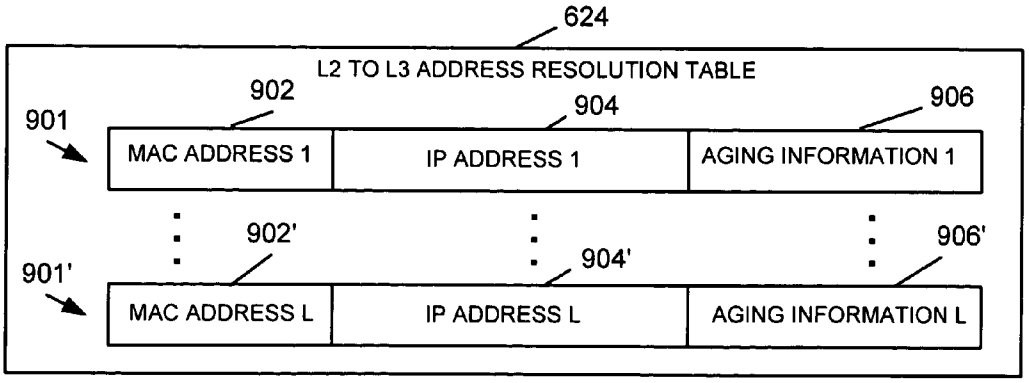


FIGURE 9

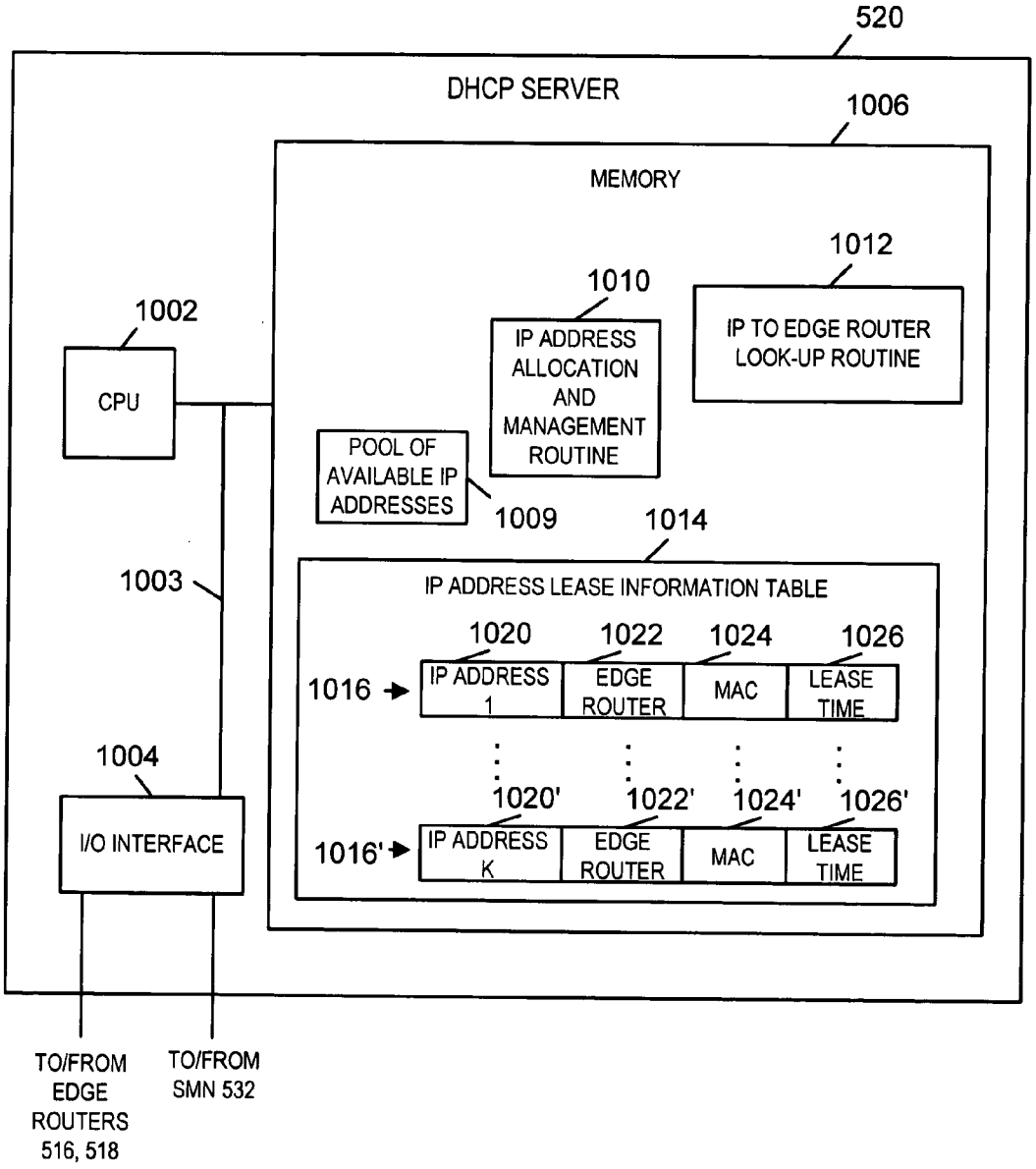

520
DHCP SERVER
1006
MEMORY
1012
1010
IP TO EDGE ROUTER LOOK-UP ROUTINE
IP ADDRESS ALLOCATION AND MANAGEMENT ROUTINE
1002
CPU
POOL OF AVAILABLE IP ADDRESSES
1009
1014
1003
IP ADDRESS LEASE INFORMATION TABLE
1020
1022
1024
1026
1016
IP ADDRESS 1
EDGE ROUTER
MAC
LEASE TIME
1004
1020'
1022'
1024'
1026'
I/O INTERFACE
1016'
IP ADDRESS K
EDGE ROUTER
MAC
LEASE TIME
TO/FROM EDGE ROUTERS 516, 518
TO/FROM SMN 532

FIGURE 10

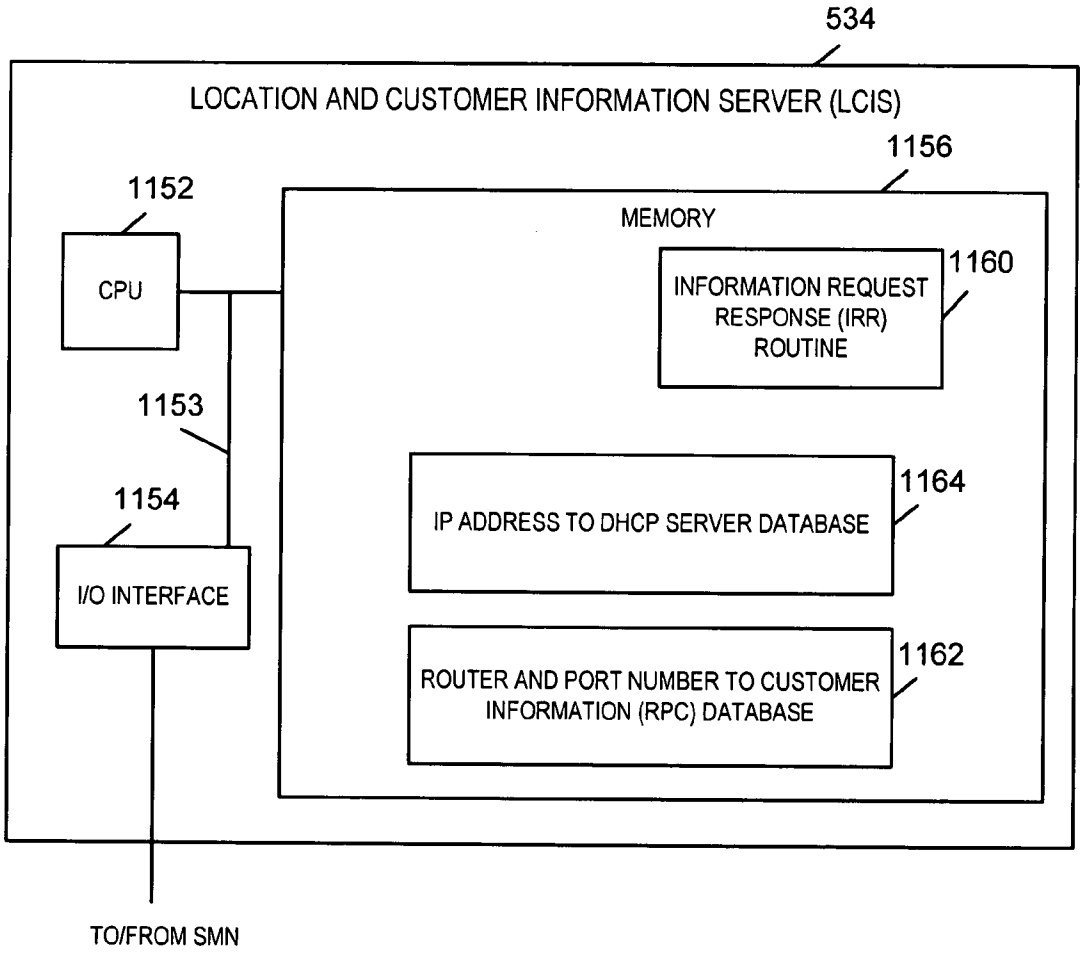

534
LOCATION AND CUSTOMER INFORMATION SERVER (LCIS)
1156
1152
MEMORY
CPU
INFORMATION REQUEST RESPONSE (IRR) ROUTINE
1160
1153
1164
1154
IP ADDRESS TO DHCP SERVER DATABASE
I/O INTERFACE
1162
ROUTER AND PORT NUMBER TO CUSTOMER INFORMATION (RPC) DATABASE
TO/FROM SMN

FIGURE 11

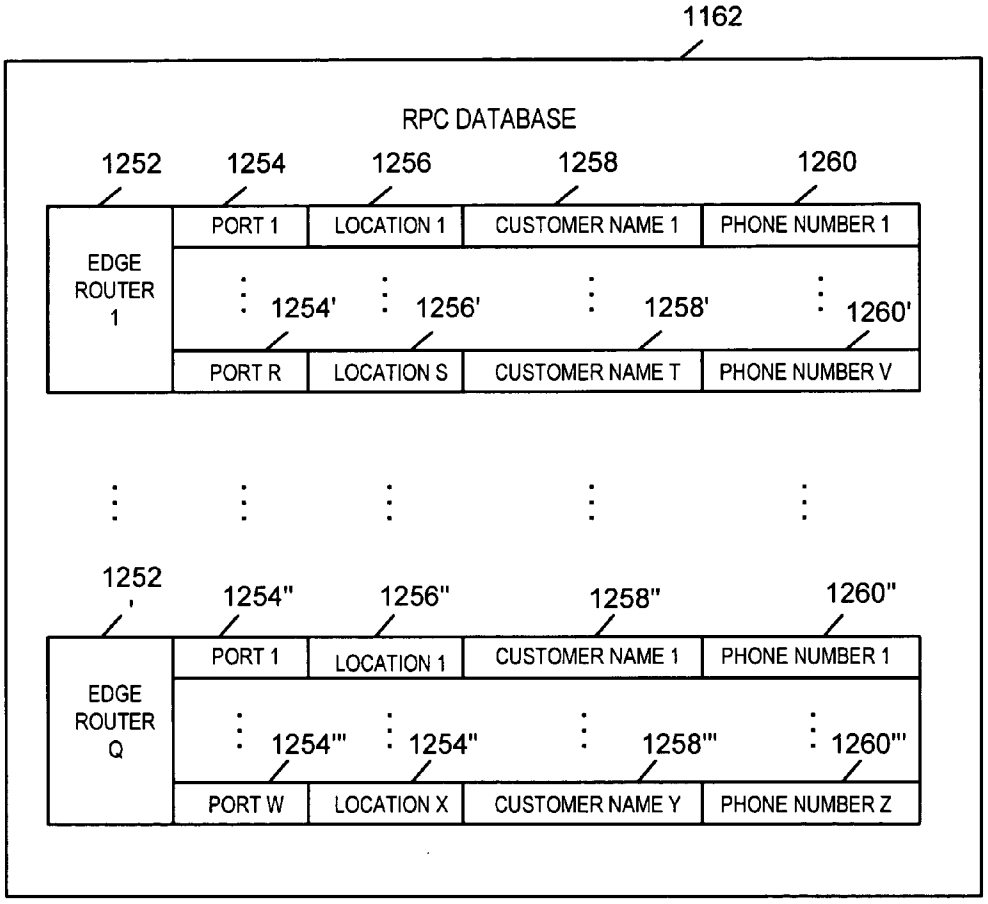

1162
RPC DATABASE
1252
1254
1256
1258
1260
EDGE ROUTER 1
PORT 1
LOCATION 1
CUSTOMER NAME 1
PHONE NUMBER 1
1254'
1256'
1258'
1260'
PORT R
LOCATION S
CUSTOMER NAME T
PHONE NUMBER V
1252'
1254"
1256"
1258"
1260"
EDGE ROUTER Q
PORT 1
LOCATION 1
CUSTOMER NAME 1
PHONE NUMBER 1
1254'''
1254"
1258'''
1260'''
PORT W
LOCATION X
CUSTOMER NAME Y
PHONE NUMBER Z

FIGURE 12

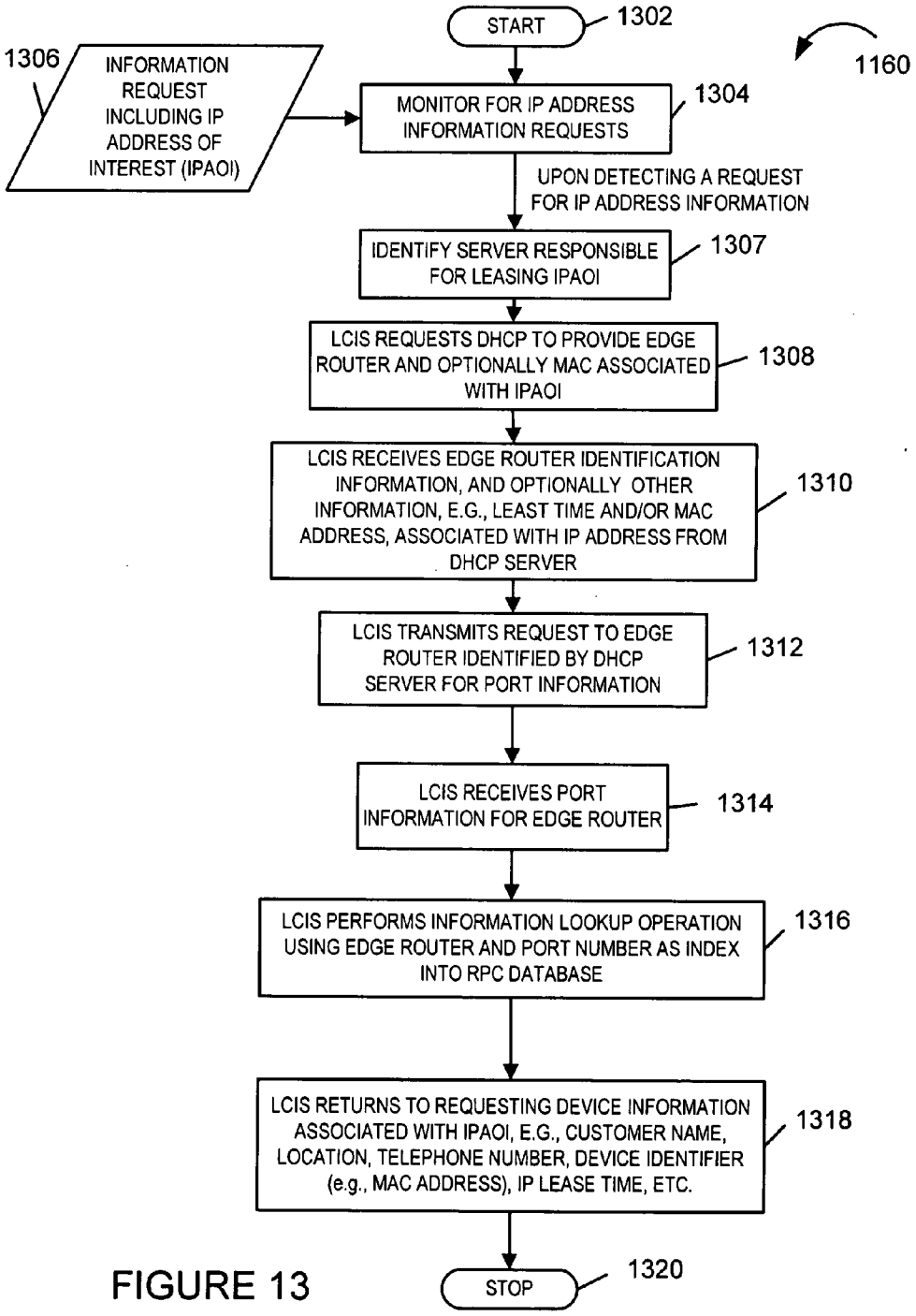

START
1302
1160
1306
INFORMATION REQUEST INCLUDING IP ADDRESS OF INTEREST (IPAOI)
MONITOR FOR IP ADDRESS INFORMATION REQUESTS
1304
UPON DETECTING A REQUEST FOR IP ADDRESS INFORMATION
IDENTIFY SERVER RESPONSIBLE FOR LEASING IPAOI
1307
LCIS REQUESTS DHCP TO PROVIDE EDGE ROUTER AND OPTIONALLY MAC ASSOCIATED WITH IPAOI
1308
LCIS RECEIVES EDGE ROUTER IDENTIFICATION INFORMATION, AND OPTIONALLY OTHER INFORMATION, E.G., LEAST TIME AND/OR MAC ADDRESS, ASSOCIATED WITH IP ADDRESS FROM DHCP SERVER
1310
LCIS TRANSMITS REQUEST TO EDGE ROUTER IDENTIFIED BY DHCP SERVER FOR PORT INFORMATION
1312
LCIS RECEIVES PORT INFORMATION FOR EDGE ROUTER
1314
LCIS PERFORMS INFORMATION LOOKUP OPERATION USING EDGE ROUTER AND PORT NUMBER AS INDEX INTO RPC DATABASE
1316
LCIS RETURNS TO REQUESTING DEVICE INFORMATION ASSOCIATED WITH IPAOI, E.G., CUSTOMER NAME, LOCATION, TELEPHONE NUMBER, DEVICE IDENTIFIER (e.g., MAC ADDRESS), IP LEASE TIME, ETC.
1318
STOP
1320

FIGURE 13

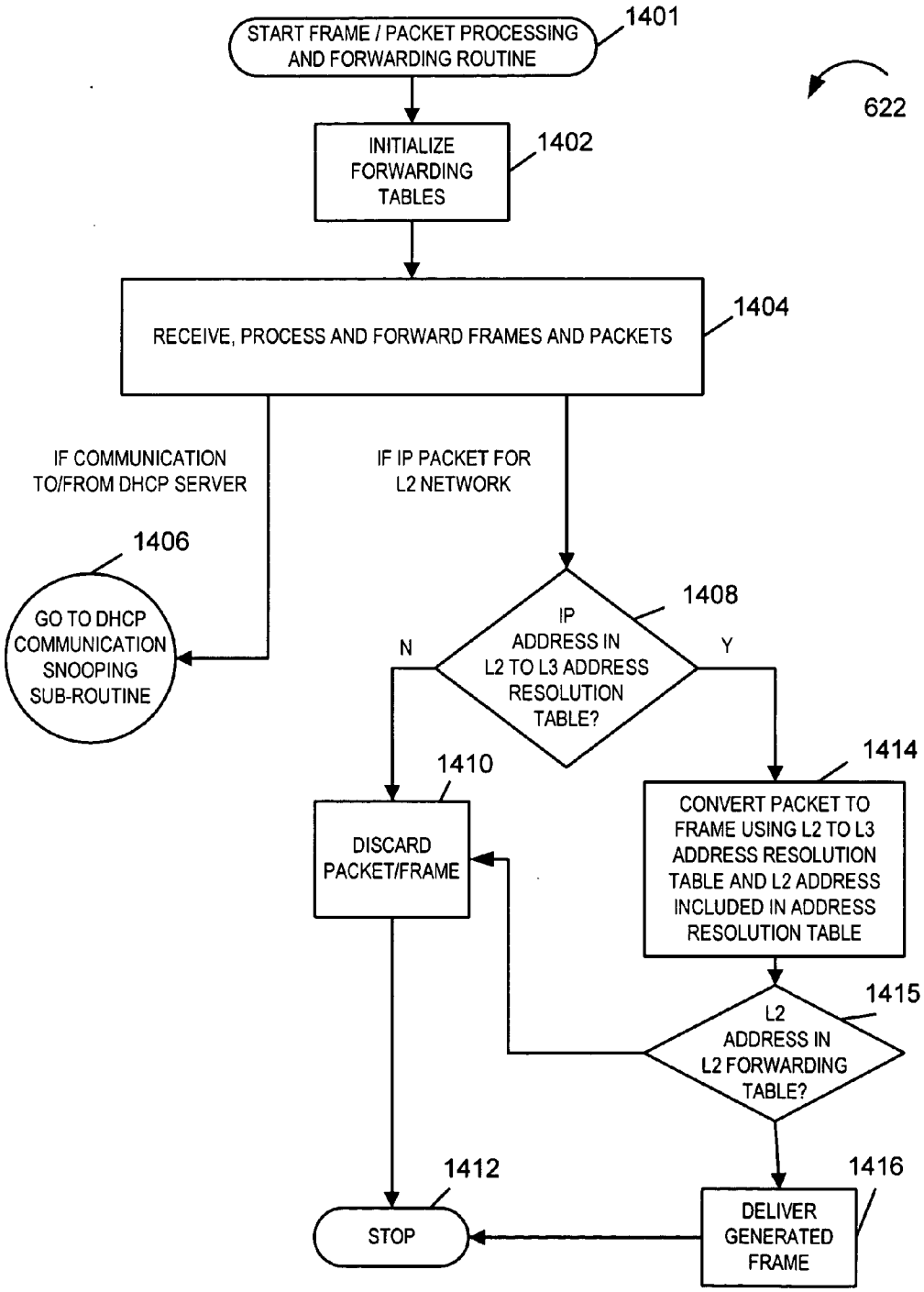

START FRAME / PACKET PROCESSING AND FORWARDING ROUTINE
1401
622
INITIALIZE FORWARDING TABLES
1402
RECEIVE, PROCESS AND FORWARD FRAMES AND PACKETS
1404
IF COMMUNICATION TO/FROM DHCP SERVER
IF IP PACKET FOR L2 NETWORK
1406
GO TO DHCP COMMUNICATION SNOOPING SUB-ROUTINE
1408
IP ADDRESS IN L2 TO L3 ADDRESS RESOLUTION TABLE?
N
Y
1410
DISCARD PACKET/FRAME
1414
CONVERT PACKET TO FRAME USING L2 TO L3 ADDRESS RESOLUTION TABLE AND L2 ADDRESS INCLUDED IN ADDRESS RESOLUTION TABLE
1415
L2 ADDRESS IN L2 FORWARDING TABLE?
1412
STOP
1416
DELIVER GENERATED FRAME

FIGURE 14

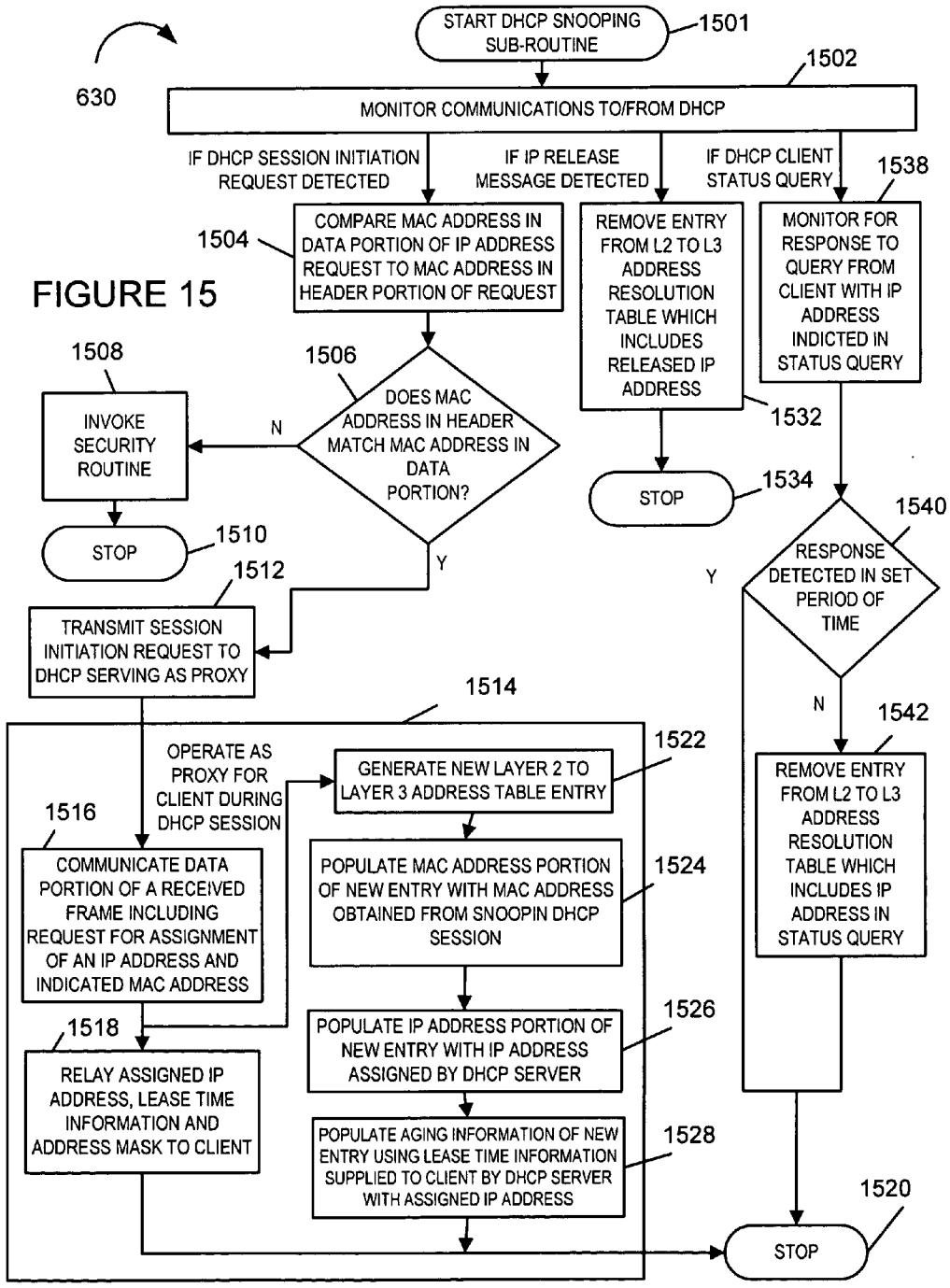
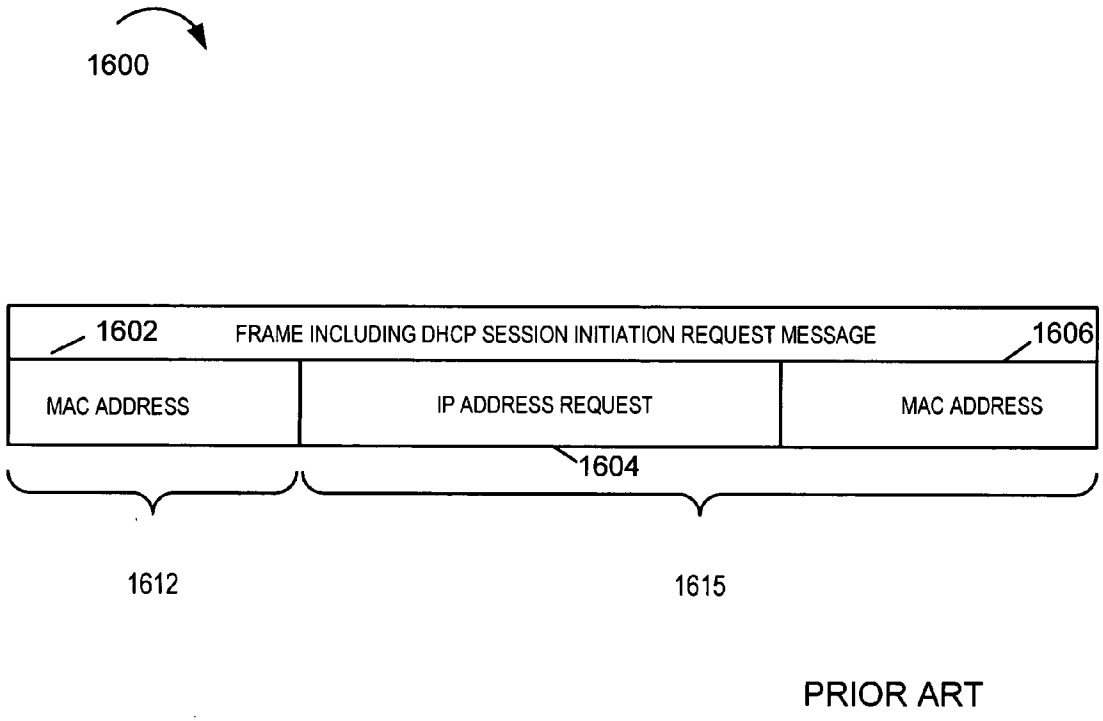

630
START DHCP SNOOPING SUB-ROUTINE
1501
1502
MONITOR COMMUNICATIONS TO/FROM DHCP
IF DHCP SESSION INITIATION REQUEST DETECTED
IF IP RELEASE MESSAGE DETECTED
IF DHCP CLIENT STATUS QUERY
1538
1504
COMPARE MAC ADDRESS IN DATA PORTION OF IP ADDRESS REQUEST TO MAC ADDRESS IN HEADER PORTION OF REQUEST
REMOVE ENTRY FROM L2 TO L3 ADDRESS RESOLUTION TABLE WHICH INCLUDES RELEASED IP ADDRESS
MONITOR FOR RESPONSE TO QUERY FROM CLIENT WITH IP ADDRESS INDICTED IN STATUS QUERY
1508
1506
INVOKE SECURITY ROUTINE
N
DOES MAC ADDRESS IN HEADER MATCH MAC ADDRESS IN DATA PORTION?
1532
STOP
1534
1540
STOP
1510
1512
Y
Y
RESPONSE DETECTED IN SET PERIOD OF TIME
TRANSMIT SESSION INITIATION REQUEST TO DHCP SERVING AS PROXY
1514
N
1542
OPERATE AS PROXY FOR CLIENT DURING DHCP SESSION
1522
GENERATE NEW LAYER 2 TO LAYER 3 ADDRESS TABLE ENTRY
REMOVE ENTRY FROM L2 TO L3 ADDRESS RESOLUTION TABLE WHICH INCLUDES IP ADDRESS IN STATUS QUERY
1516
COMMUNICATE DATA PORTION OF A RECEIVED FRAME INCLUDING REQUEST FOR ASSIGNMENT OF AN IP ADDRESS AND INDICATED MAC ADDRESS
POPULATE MAC ADDRESS PORTION OF NEW ENTRY WITH MAC ADDRESS OBTAINED FROM SNOOPIN DHCP SESSION
1524
1518
POPULATE IP ADDRESS PORTION OF NEW ENTRY WITH IP ADDRESS ASSIGNED BY DHCP SERVER
1526
RELAY ASSIGNED IP ADDRESS, LEASE TIME INFORMATION AND ADDRESS MASK TO CLIENT
POPULATE AGING INFORMATION OF NEW ENTRY USING LEASE TIME INFORMATION SUPPLIED TO CLIENT BY DHCP SERVER WITH ASSIGNED IP ADDRESS
1528
1520
STOP

FIGURE 15



PRIOR ART

FIGURE 16

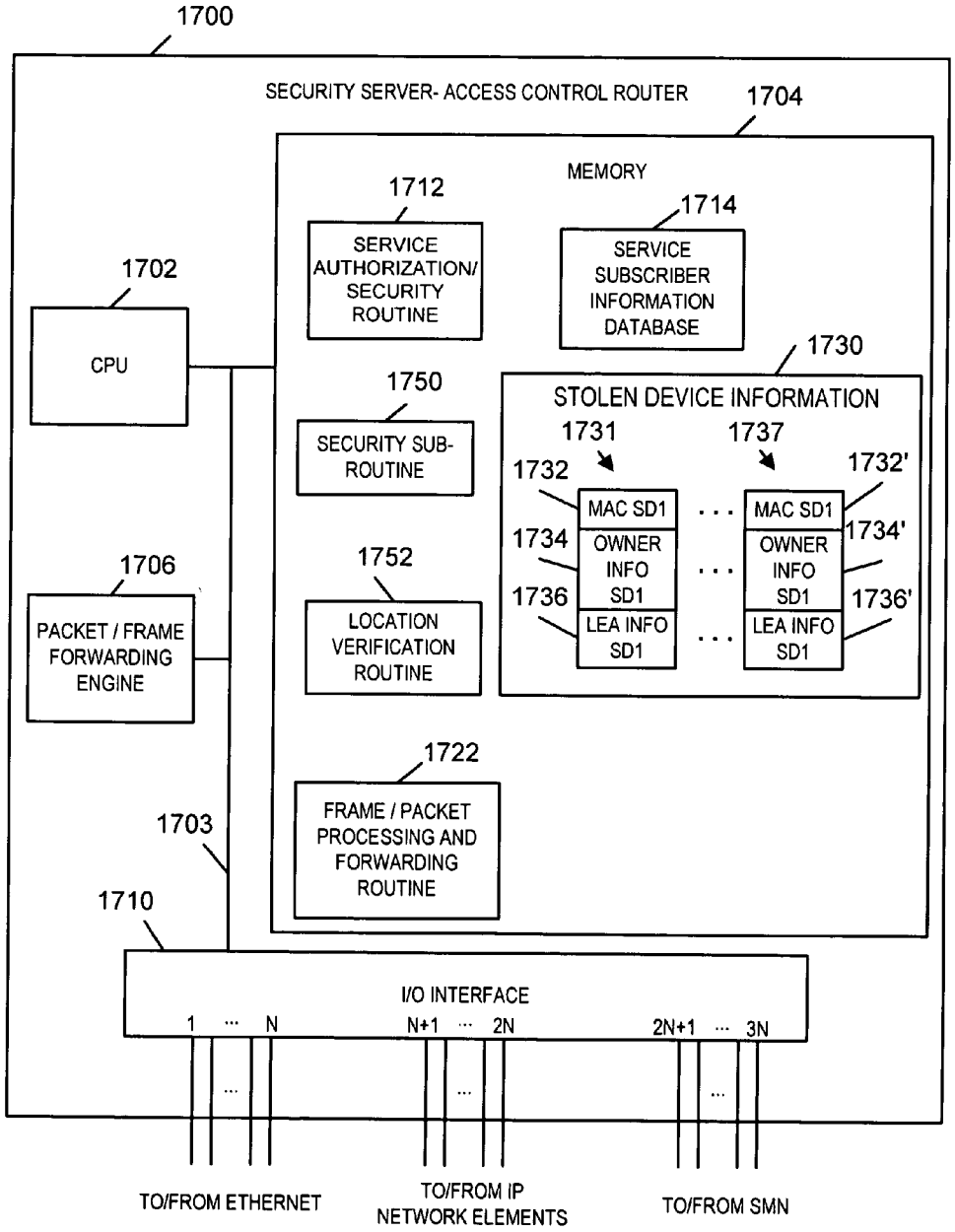

1700
SECURITY SERVER- ACCESS CONTROL ROUTER
1704
MEMORY
1712
SERVICE AUTHORIZATION/ SECURITY ROUTINE
1714
SERVICE SUBSCRIBER INFORMATION DATABASE
1702
CPU
1730
STOLEN DEVICE INFORMATION
1750
SECURITY SUB-ROUTINE
1731
1737
1732
1732'
MAC SD1
MAC SD1
1734
1734'
OWNER INFO SD1
OWNER INFO SD1
1752
1706
1736
1736'
LOCATION VERIFICATION ROUTINE
PACKET / FRAME FORWARDING ENGINE
LEA INFO SD1
LEA INFO SD1
1722
FRAME / PACKET PROCESSING AND FORWARDING ROUTINE
1703
1710
I/O INTERFACE
1 ... N
N+1 ... 2N
2N+1 ... 3N
TO/FROM ETHERNET
TO/FROM IP NETWORK ELEMENTS
TO/FROM SMN

FIGURE 17

1714

SUBSCRIBER SERVICE INFORMATION DATABASE

	1802	1804	1806	1808	1810	1812	1814
	NAME	PHYSICAL LOCATION	SERVICE INFO	ROUTER/ PORT	MAC	IP ADDRESS	IP ADDRESS LEASE TIME INFORMATION
1820	JOHN SMITH	120 SPRING ST LODI, N.J.	VOD- VOD IP ADDRESS	ER2/PORT 1	MAC 1	IP ADDRESS 1	EXPIRES 15:00 7/14/03
1822	JIM JONES	670 RED LANE FARWAY, NJ	VOD/MOD VOD IP ADDRESS MOD IP ADDRESS	ER1/PORT 6	MAC 2	IP ADDRESS 2	EXPIRES 16:00 7/14/03
	. . .	. . .	. . .	. . .	. . .	. . .	. . .
1823	BOB EVENS	60 BLUE LANE FARWAY, NJ	BANKING FROM HOME-BANK IP ADDRESS	-------	-------	---------	----------
1824	JANE ROGERS	720 HOPE RD RED BANK, NJ	VOD VOD IP ADDRESS	---------	-------	---------	----------
1825	BILL THEIF	98 REFORM RD RED BANK, NJ	LOC VER-LOC VER IP ADDRESS; EXPECTED LOCATION/ TIME(S); REPORT INFORMAT-ION; REORTING DEVICE MAC ADDRESS	---------	-------	---------	----------

FIGURE 18

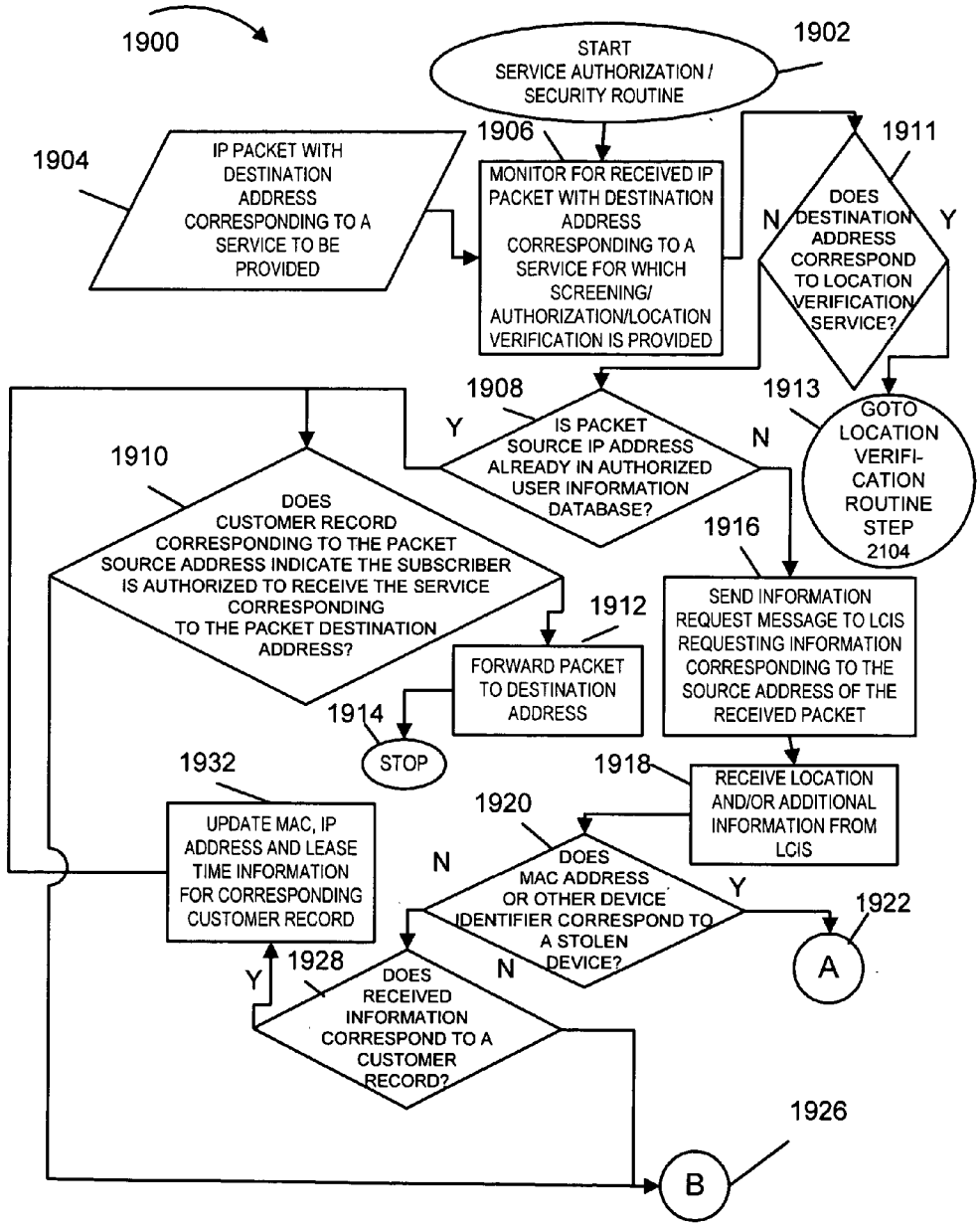

1900
START SERVICE AUTHORIZATION / SECURITY ROUTINE
1902
1904
IP PACKET WITH DESTINATION ADDRESS CORRESPONDING TO A SERVICE TO BE PROVIDED
1906
MONITOR FOR RECEIVED IP PACKET WITH DESTINATION ADDRESS CORRESPONDING TO A SERVICE FOR WHICH SCREENING/ AUTHORIZATION/LOCATION VERIFICATION IS PROVIDED
1911
DOES DESTINATION ADDRESS CORRESPOND TO LOCATION VERIFICATION SERVICE?
N
Y
1908
IS PACKET SOURCE IP ADDRESS ALREADY IN AUTHORIZED USER INFORMATION DATABASE?
Y
N
1913
GOTO LOCATION VERIFI-CATION ROUTINE STEP 2104
1910
DOES CUSTOMER RECORD CORRESPONDING TO THE PACKET SOURCE ADDRESS INDICATE THE SUBSCRIBER IS AUTHORIZED TO RECEIVE THE SERVICE CORRESPONDING TO THE PACKET DESTINATION ADDRESS?
1916
SEND INFORMATION REQUEST MESSAGE TO LCIS REQUESTING INFORMATION CORRESPONDING TO THE SOURCE ADDRESS OF THE RECEIVED PACKET
1912
FORWARD PACKET TO DESTINATION ADDRESS
1914
STOP
1932
UPDATE MAC, IP ADDRESS AND LEASE TIME INFORMATION FOR CORRESPONDING CUSTOMER RECORD
1918
RECEIVE LOCATION AND/OR ADDITIONAL INFORMATION FROM LCIS
1920
DOES MAC ADDRESS OR OTHER DEVICE IDENTIFIER CORRESPOND TO A STOLEN DEVICE?
N
Y
1922
A
1928
DOES RECEIVED INFORMATION CORRESPOND TO A CUSTOMER RECORD?
Y
N
1926
B

FIGURE 19

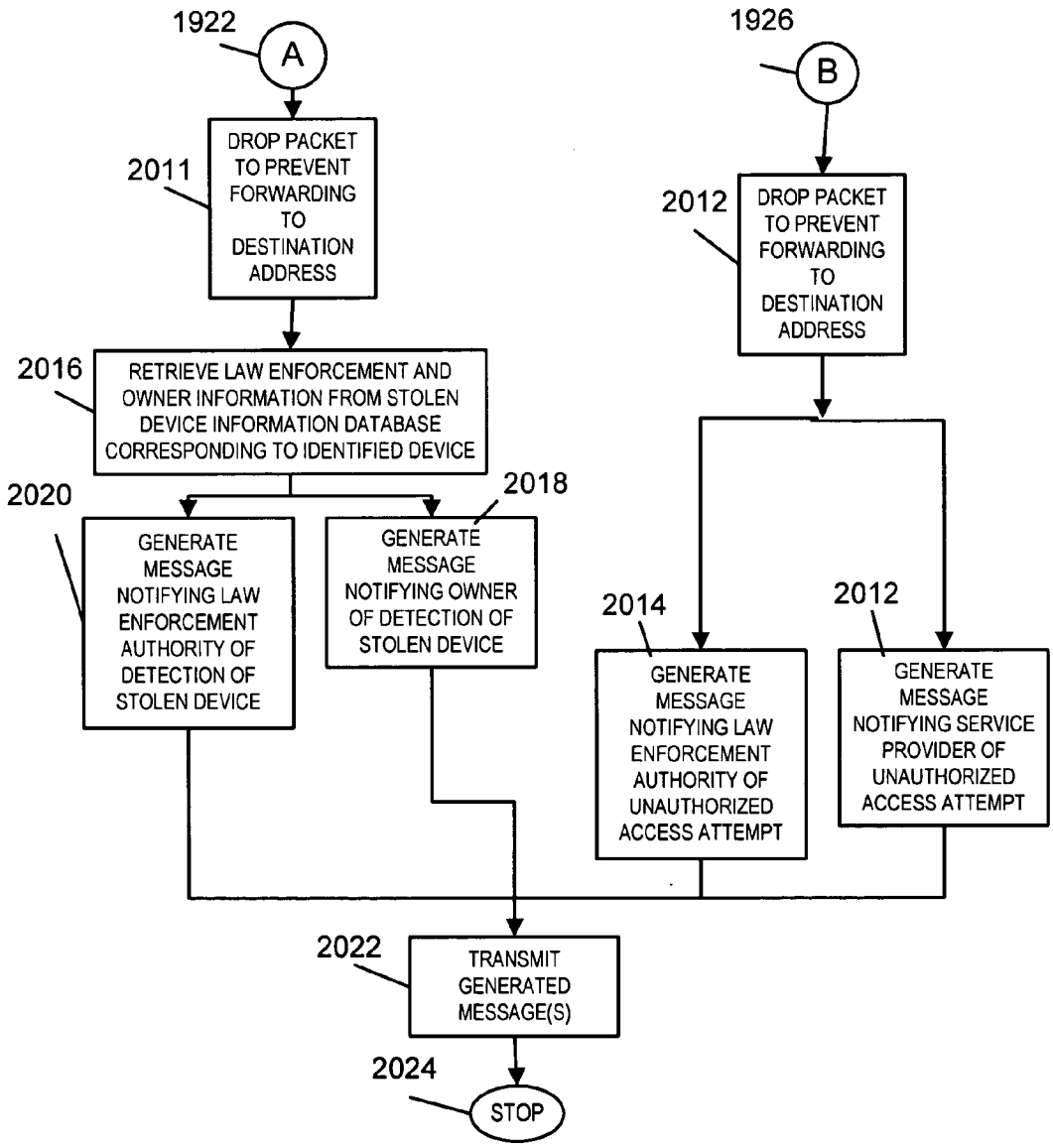

1922
A
1926
B
2011
DROP PACKET TO PREVENT FORWARDING TO DESTINATION ADDRESS
2012
DROP PACKET TO PREVENT FORWARDING TO DESTINATION ADDRESS
2016
RETRIEVE LAW ENFORCEMENT AND OWNER INFORMATION FROM STOLEN DEVICE INFORMATION DATABASE CORRESPONDING TO IDENTIFIED DEVICE
2020
GENERATE MESSAGE NOTIFYING LAW ENFORCEMENT AUTHORITY OF DETECTION OF STOLEN DEVICE
2018
GENERATE MESSAGE NOTIFYING OWNER OF DETECTION OF STOLEN DEVICE
2014
GENERATE MESSAGE NOTIFYING LAW ENFORCEMENT AUTHORITY OF UNAUTHORIZED ACCESS ATTEMPT
2012
GENERATE MESSAGE NOTIFYING SERVICE PROVIDER OF UNAUTHORIZED ACCESS ATTEMPT
2022
TRANSMIT GENERATED MESSAGE(S)
2024
STOP

FIGURE 20

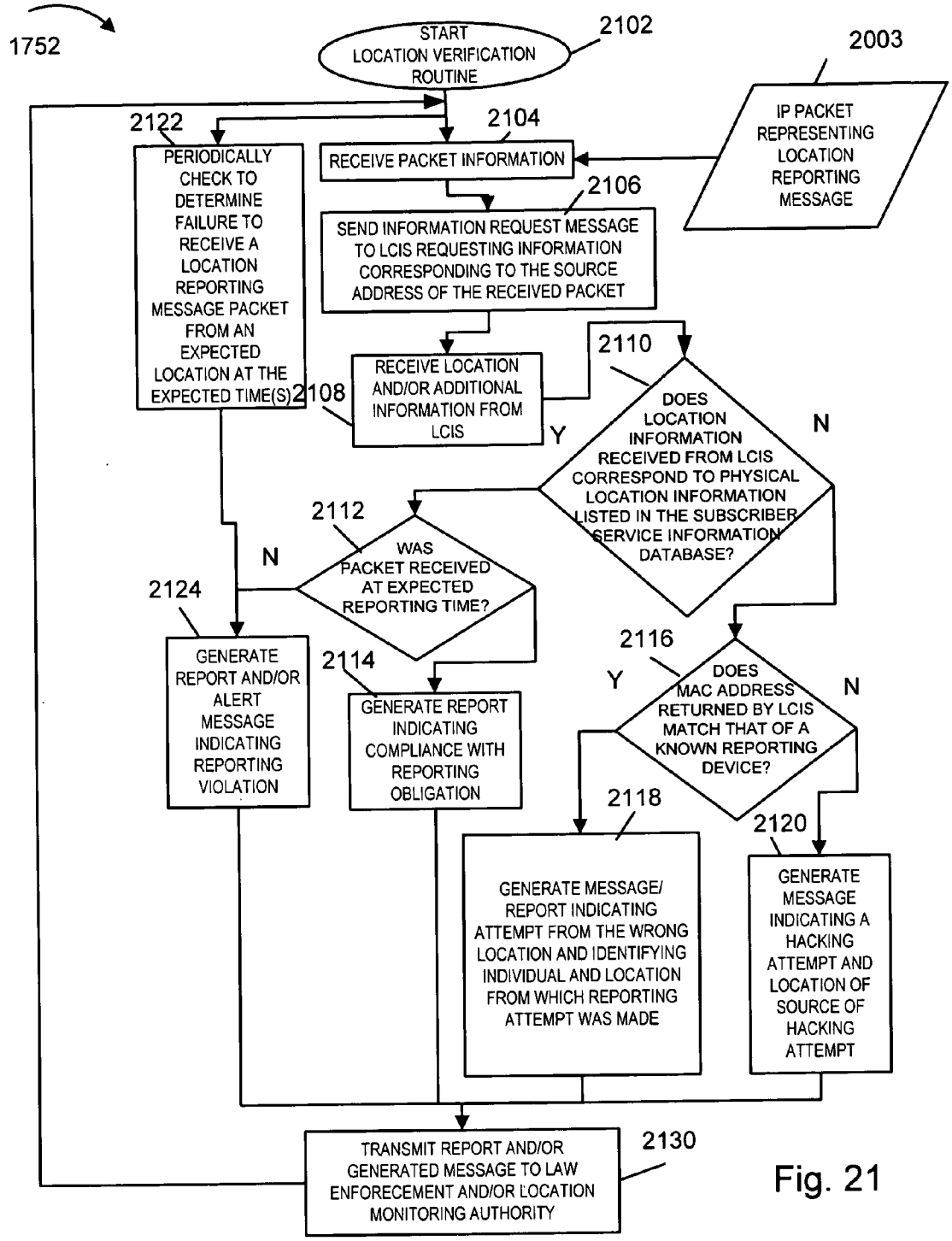

1752
START LOCATION VERIFICATION ROUTINE
2102
2003
IP PACKET REPRESENTING LOCATION REPORTING MESSAGE
2122
PERIODICALLY CHECK TO DETERMINE FAILURE TO RECEIVE A LOCATION REPORTING MESSAGE PACKET FROM AN EXPECTED LOCATION AT THE EXPECTED TIME(S)
2104
RECEIVE PACKET INFORMATION
2106
SEND INFORMATION REQUEST MESSAGE TO LCIS REQUESTING INFORMATION CORRESPONDING TO THE SOURCE ADDRESS OF THE RECEIVED PACKET
2108
RECEIVE LOCATION AND/OR ADDITIONAL INFORMATION FROM LCIS
2110
DOES LOCATION INFORMATION RECEIVED FROM LCIS CORRESPOND TO PHYSICAL LOCATION INFORMATION LISTED IN THE SUBSCRIBER SERVICE INFORMATION DATABASE?
Y
N
2112
WAS PACKET RECEIVED AT EXPECTED REPORTING TIME?
N
2124
GENERATE REPORT AND/OR ALERT MESSAGE INDICATING REPORTING VIOLATION
2114
GENERATE REPORT INDICATING COMPLIANCE WITH REPORTING OBLIGATION
2116
DOES MAC ADDRESS RETURNED BY LCIS MATCH THAT OF A KNOWN REPORTING DEVICE?
Y
N
2118
GENERATE MESSAGE/ REPORT INDICATING ATTEMPT FROM THE WRONG LOCATION AND IDENTIFYING INDIVIDUAL AND LOCATION FROM WHICH REPORTING ATTEMPT WAS MADE
2120
GENERATE MESSAGE INDICATING A HACKING ATTEMPT AND LOCATION OF SOURCE OF HACKING ATTEMPT
2130
TRANSMIT REPORT AND/OR GENERATED MESSAGE TO LAW ENFORECEMENT AND/OR LOCATION MONITORING AUTHORITY

Fig. 21

IP BASED SECURITY APPLICATIONS USING LOCATION, PORT AND/OR DEVICE IDENTIFIER INFORMATION

RELATED APPLICATIONS

[0001] The present invention claims the benefit of U.S. Provisional Patent Application S. No. 60/455,353, filed Mar. 17, 2003 titled "Methods and Apparatus For Supporting IP Telephony"; is a continuation-in-part of U.S. Utility patent application Ser. No. 10/457,111, filed Jun. 9, 2003 titled "Methods And Apparatus For Providing Emergency Telephone Service to IP-Based Telephone Users"; is a continuation-in-part of U.S. Utility patent application Ser. No. 10/457,107, filed on Jun. 9, 2003 titled "Methods And Apparatus For Wiretapping IP-Based Telephone Lines"; and is a continuation-in-part of U.S. Utility patent application Ser. No. 10/337,106, filed on Jan. 6, 2003 titled "Methods And Apparatus For Determining The Port And/Or Physical Location Of An IP Device And For Using That Information" which claims the benefit of U.S. Provisional Patent Application S. No. 60/346,596, filed Jan. 8, 2002 titled "Methods And Apparatus For Determining The Port And/Or Physical Location Of An IP Device And For Using That Information" each of which is hereby expressly incorporated by reference.

FIELD OF THE INVENTION

[0002] The present invention is directed to communications systems and, more particularly, to methods and apparatus for providing security, authorization and/or screening services in IP communications systems, e.g. networks.

BACKGROUND OF THE INVENTION

[0003] Digital communications networks have continued to grow in importance as people have come to rely on the electronic exchange of information to support both business and personal pursuits. E-mail, the electronic transfer of files, and various other services are made possible by the use of digital communications networks.

[0004] The type of digital communications network employed often depends on the size of the network to be implemented, as well as the needs and capabilities of the party or parties implementing the network. Hardware cost and network management complexity are often a factor when choosing the type of network to be implemented.

[0005] Networks limited to a small geographical region, e.g., home or single office location, are frequently called local area networks ("LANs"). LANs are often privately-owned networks within a single building or small campus. LANS are widely used to connect personal computers and workstations at a single location, e.g., company office or residence, to one another and to shared resources such as printers and/or local centralized file storage.

[0006] One popular type of LAN, an IEEE 802.3 standard based LAN is popularly called Ethernet. Ethernet is a bus based broadcast network with decentralized control. When using Ethernet, data, e.g., messages, information and signals are transmitted in Ethernet using frames. Ethernet devices broadcast and receive frames over the shared bus over which the frames are broadcast. The format of an IEEE 802.3 frame **100** is shown in **FIG. 1**. Each frame **100** starts with a 7 byte preamble **102** containing a preset bit pattern. The preamble **102** is followed by a start of frame byte **104** which includes the bit pattern 10101011 used to denote the start of the frame. Next come two addresses, a destination address **106** and a source address **108**. The high-order bit of the destination address is a 0 for ordinary addresses and 1 for group addresses. Group addresses, in contrast to individual device addresses, allow multiple stations, e.g., devices coupled to the Ethernet, to receive frames including a single group address. When a frame is sent to a group address, all the stations in the group receive it. Sending to a group of stations is called a multicast. The address consisting of all 1 bits is reserved for broadcast. A frame containing all is in the destination field, indicating a broadcast, is delivered to all stations on the network.

[0007] Six byte global Media Access Control (MAC) Ethernet device addresses are assigned by a central authority to ensure that no two stations on the same Layer 2 network, e.g., Ethernet LAN, have the same global address. Manufacturers of Ethernet devices, e.g., networking boards, request a block of addresses from the central authority to assure that no two Ethernet boards are assigned the same global MAC address. The boards then send and receive frames based on the 48-bit MAC address programmed into the board by the manufacturer. Because source MAC address information is inserted into Ethernet frames by the Ethernet boards, the source address **108** in an Ethernet frame is usually accurate and is difficult to fake.

[0008] Since Ethernet MAC address are unique at least on the same Layer 2 network and potentially globally, any device on a Layer 2 network can address any other device on the network by just using the right 48 bit MAC address assigned to the device being addressed.

[0009] MAC addresses are data link layer addresses. The data link layer corresponds to the second layer of the seven layer OSI (Open Systems Interconnection) Reference Model. As a result, Ethernet LANs and other LANS which use data link layer addresses are sometimes called Layer 2 networks.

[0010] In addition to the address information **106**, **108** the Ethernet frame includes a length of data field **110**, data field **112**, padding field **114** and a checksum field **116**. As will be discussed below, information intended to be transmitted over an IP based network may be included in the data field **112**.

[0011] While Layer 2 networks are well suited for implementing LANs, e.g., at relatively small sites, it is often desirable to connect devices, e.g., computers located on different LANs. Layer 3 networks, which rely on network protocols, e.g. TCP/IP protocols, are often used for interconnecting Layer 2 networks. Layer 3 packets, e.g., IP packets, are often encapsulated in Layer 2 frames to extend the reach of the Layer 3 network to host devices on the Layer 2 network. This permits Layer 2 signaling and frames to be used for transmissions of data over the Ethernet while preserving Layer 3 addressing information for transmission over the Layer 3 network. The network resulting from interconnecting one or more Layer 2 and Layer 3 networks is often referred to as an internet.

[0012] The Internet is a well-known worldwide internet that is used to connect computers and other devices located at universities, governments offices, businesses and individuals together.

[0013] **FIG. 2** is an extremely simplistic representation of the Internet **200**. As illustrated, the Internet **200** includes a plurality, e.g., first and second, Layer 2 networks **201**, **203**, coupled. together by a Layer 3 network **205**. While only two Layer 2 networks, e.g., Ethernet LANs, are shown, many thousands of such networks may be part of the Internet. Edge routers, e.g., multi-protocol routers, capable of converting between Layer 2 and Layer 3 formats and addressing schemes, are often used to connect Layer 2 networks to Layer 3 networks. In **FIG. 2**, first edge router **216**, connects the first Layer 2 network **201** to the Layer 3 network **205**. Similarly the second edge router **218** connects the second Layer 2 network **203** to the Layer 3 network **205**.

[0014] In the **FIG. 2** example, two host devices **208**, **210** are shown coupled to the first Ethernet bus **204**, used to implement the Ethernet LAN **201**, while third and fourth host devices **212**, **214** are shown coupled to the second Ethernet bus **206** used to implement Ethernet LAN **203**. While only two hosts are shown on each Ethernet LAN it is to be understood that a large number of hosts may be coupled to any one of the Layer 2 networks, corresponding to Ethernet busses **204**, **206**, at any given time.

[0015] Routers, serve as forwarding devices and, optionally, protocol conversion devices. In the **FIG. 2** diagram, edge routers **216** and **218** have the capability of converting between Ethernet frames and IP packets, and vice versa, using one or more tables relating IP addresses to MAC addresses.

[0016] Routers **222**, **224**, **226** and **228** internal to the Layer 3 network form part of what is sometimes called the Internet backbone. Since these routers do not need to handle Ethernet frames, they do not include the protocol conversion functionality present in the edge routers **216**, **218**. Groups of routers **216**, **218**, **222**, **224**, **226**, **228** managed by a single administrator is often called an Autonomous System (AS). The Internet includes several AS which are connected to each other. Each AS may include one or more DHCP (Dynamic Host Configuration Protocol) servers which are responsible for assigning IP addresses to host devices connected to the AS. In **FIG. 2, a** single DHCP server **220** is shown coupled to edge routers **216**, **218**.

[0017] Unlike LANs which use data link layer addresses, the Internet uses Layer 3 (Network layer) addresses, e.g., IP Addresses, for purposes of identifying source and destination devices and determining the appropriate route upon which packets should be transmitted. Source and destination IP addresses are included, along with data, in IP packets used to transmit information across the Internet. Every host and router on the Internet has an IP address which encodes its IP network number and host number. The combination is unique, no two machines have the same IP address.

[0018] Exemplary IP addresses are 32 bits long and are used in the Source address and Destination address fields of IP packets. **FIG. 3** is a diagram **300** which illustrates the standard 32 bit format for IP addresses. Note that host addresses are divided into different classes (A, B, C) with different numbers of bits allocated to the network number and host portion number in each address class. From a management perspective, system administrators may divide the host number portion of a 32 bit IP address into a subnet portion **402** and a host portion **404** as illustrated in block **400** of **FIG. 4**. In such embodiments, within the network defined by the network portion of the IP address, a subnet mask is used at the routers within the network to distinguish between the host portion **404** and the rest of the 32 bit IP address and thereby allow for routing within the network based on the subnet portion of the address.

[0019] The demand for IP address continues to grow and, with fewer bits than are used for MAC addresses, there are considerably fewer IP addresses available for allocation. Given the demand for IP addresses and the limited supply, IP addresses are leased from a central authority responsible for overseeing their allocation. Internet service providers, may lease a large number, e.g., a block of IP addresses, which the provider then sub-leases to end users, e.g., host devices.

[0020] As a result of the lease (actually the sub-lease) process, end users obtain an IP address which is subject to lease restrictions including the right to use the IP address for a limited period of time. IP addresses leased for extended periods of time, e.g., a year or more, are often termed "static" IP addresses. Static IP addresses are used for applications such as Web site hosting where the Internet connection is likely to remain active and in use for extended periods of time. Users normally pay a premium for static IP addresses.

[0021] With regard to individual Internet users, IP addresses are more commonly leased to end users on a dynamic basis. Internet service providers frequently use a DHCP server to assign users IP addresses for a limited lease time when they seek to access the Internet, e.g., from a host device coupled to the Internet by way of a Layer 2 network. **FIG. 2** illustrates a single DHCP server **220** coupled to the two edge routes **216**, **218** to oversee IP address allocation. In practice, the Layer 3 network **202** may include multiple DHCP servers with each server being responsible for allocating IP addresses to users on a different network or subnet. The system administrator responsible for overseeing an AS determines the relationship between DHCP servers, sets of IP addresses allocated by each of the DHCP servers and the edge routes which connect users to the DHCP servers for IP address assignment.

[0022] Once an IP address is leased to a host, e.g., user, if the host remains active beyond the lease term, the lease may be extended or a new IP address assigned to the host from the available pool of IP addresses at the end of the first lease term.

[0023] When a user intends to stop using the IP address, the user's device, e.g., host device **208**, normally signals to the DHCP server that assigned the IP address that the address is being released. This allows the address to be added to the pool of available addresses and reused. In the event that a release message is not received prior to the IP address lease timing out, and the DHCP server encounters a shortage of addresses in the pool of available addresses, the DHCP server may poll devices to which it allocated IP addresses to see if they are still active. Failure to receive a response may result in the DHCP adding the IP address assigned to the non-responding device back into the pool of available IP addresses.

[0024] Thus, unlike MAC address which are fixed for the life of a product by the manufacturer, the IP address assigned to a particular host device can change from moment to

moment. Accordingly, in contrast to MAC addresses which are fixed for the life of a product by the manufacturer, there is no permanent fixed relationship between a physical device and the IP address assigned to the device.

[**0025**] Many contemplated IP applications could benefit from reliable information about the location and/or identity of a host device using an IP address. The dynamic allocation of IP addresses and re-use of IP addresses discussed above, greatly complicates attempts to accurately correlate specific devices and/or physical locations with an IP address.

[**0026**] The problem of associating IP addresses with physical locations is further complicated by the manner in which IP addresses are assigned and used. Blocks of IP addresses are assigned by the central authority to different network providers based on the size of their networks. Unlike zip codes or telephone number area codes, assignment of IP addresses is independent of geographic location. Accordingly, IP addresses do not inherently convey geographic location information as do, for example, zip codes used by the post office or the area code portion of a telephone number.

[**0027**] Reliable location information is also difficult to obtain in an IP network because IP based routing relies, in most cases, on the intelligence of the network to determine the routing path to a specified destination address. The host need not, and in most cases does not, know the physical location of the destination device to which it is sending packets or the route over which the transmitted packets will be conveyed. In addition, routers in an IP network usually only need to determine the next router in a path based on an IP address and therefore often do not include detailed topology information relating to large portions of an IP network. While shielding end devices and routers from having to make end to end routing decisions has many advantages, the lack of information about the physical devices corresponding to IP addresses poses problems in many contemplated IP based applications.

[**0028**] IP based services, those based on private internets and the larger Internet are continuing to grow in importance. IP and the Internet are beginning to be used for a wide range of applications such as music file sharing, news delivery, software distribution, etc. IP and Internet applications which are expected to grow in importance in the future include Internet telephony and video on demand services. In the case of Internet telephony voice signals are exchanged over the Internet through the use of packets including voice data.

[**0029**] As the use of IP addresses for a wide variety of services continues to grow, security becomes an ever-increasing issue, e.g., it is undesirable to assign IP addresses to a device based on fraudulent information. As can be appreciated, the assignment of IP addresses based on fraudulent information makes tracking an accountability difficult and has the potential of allowing an individual to steal services, e.g., Internet or other IP services in a manner that may not be traceable using existing systems.

[**0030**] One potential way of obtaining IP addresses assignments based on fraudulent information which has presented service providers with a problem will now be explained with reference to **FIG. 16**.

[**0031**] As discussed above, IP addresses are frequently assigned to devices on a dynamic basis. Devices requesting assignment of an IP address may be coupled to an IP network via an Ethernet or other LAN. An edge router serves to interconnect the LAN and IP based network. Assignment of IP addresses is performed by a DHCP server.

[**0032**] MAC addresses are used for addressing purposes in Layer 2 networks, e.g., Ethernet LANs, which communicate information using frames. In contrast, IP addresses are used for routing purposes in Layer 3 networks, e.g. IP networks, which communicate information using packets. MAC addresses are assigned by hardware manufactures and are programmed into communications devices at the time of manufacture. The manufacturer assigned MAC address is inserted by the device hardware into the header of each frame generated by the device. As a result, MAC addresses included in the headers of Ethernet frames tend to be reliable. The contents of the data portion of an Ethernet frame are determined by software which can be manipulated with relative ease. Accordingly, MAC addresses included in the data portion of frames are considerable less reliable then the MAC address in the frame header. The MAC address in the data portion of a frame is sometime faked by users seeking to hide their identity, e.g., when seeking an IP address.

[**0033**] In contrast to MAC addresses which are assigned by device manufacturers, IP addresses are frequently assigned to devices on a dynamic basis by DHCP servers.

[**0034**] Edge routers are used to couple Layer 2, e.g., Ethernet LANs, to Layer 3 networks, e.g., IP networks. In order to support routing between the two networks, the edge router normally includes two tables, e.g., a Layer 2 forwarding table and a Layer 3 to Layer 2 address resolution table. The Layer 2 forwarding table includes information associating router ports with Layer 2 (MAC) addresses. The address resolution table includes information associating IP addresses with MAC addresses.

[**0035**] The Layer 2 forwarding table is normally created from header information received in Ethernet frames. This is done by having the edge router store the MAC address obtained from an Ethernet frame in the Layer 2 forwarding table along with information identifying the port on which the frame including the header was received. Frames subsequently received by the edge router directed to the stored MAC address will be output via the port indicated in the Layer 2 forwarding table. Since the information in the Layer 2 forwarding table is obtained from Ethernet Frame headers it tends to be reliable.

[**0036**] As mentioned above, in order to communicate over an IP network, a device on an Ethernet LAN is required to first obtain an IP address. To obtain the IP address, the device sends an IP address request message to an edge router in an Ethernet frame. In response to the request, the edge router populates the Layer 2 forwarding table with the MAC information obtained from the frame's header. In addition, the edge router, normally acts as a proxy for the requesting device, and initiates a DHCP communications session between the DHCP server and the requesting device. **FIG. 16** illustrates an exemplary Ethernet frame **1600** which includes a header **1612** which includes a MAC address **1602** and a payload also called a message body **1615**. The payload **1615** includes data, e.g., includes an IP address request **1604** and a corresponding MAC address **1606**. The data **1604**, **1606** represents the body of the frame, at least the MAC

address portion **1606** of which may be forwarded to a DHCP sever, e.g., by an edge router acting as a proxy for the requesting device. The MAC address **1602** in the header **1612** will normally not be forwarded to the DHCP server.

[**0037**] As part of the DHCP communications session, the requesting device transmits to the DHCP server a MAC address, e.g., MAC address **1606**. The transmitted MAC address, included in the data field **1615** of an Ethernet frame may be faked. The DHCP server will assign an IP address based on the communicated, possibly fake, MAC address. It also stores the assigned IP address, associated MAC address and lease time information in a DHCP server database. The assigned IP address is communicated to the requesting device, along with lease time, e.g., duration (lease expiration), information by way of the edge router.

[**0038**] In existing systems, when an edge router receives an IP address which is not already in its address resolution table, e.g., due to the receipt of a previous message directed to the IP address, it will broadcast an ARP (address resolution protocol) message over the LAN asking for the device which owns the IP address to respond and identify itself. Normally, the device to which the IP address was assigned will respond to the ARP message with its true MAC address. The information from the ARP message response is used to populate the edge router's address resolution table. As a result of the use of ARP and a faked MAC address, the edge router's address resolution table may end up being inconsistent with the DHCP server's database.

[**0039**] In view of the above discussion, there is a need for methods and apparatus for monitoring improving security with regard to IP address assignments and Layer 2/Layer 3 routing tables in edge routes.

[**0040**] Beyond the issue of making sure IP address assignments are based on accurate MAC address information there are several other security/access control issues relating to the use of IP addresses which may be leased. These issues come up independent of the issue of possible IP address leases being based on inaccurate MAC address information.

[**0041**] There are a large number of applications, e.g., security related applications, where it would be useful if the physical location of a device using an IP address could be determined from its IP address in a reliable manner. However, the complexities of dynamic IP address assignment along with the complexities of determining the location of a device using an IP address have made it difficult to obtain reliable location information based on an IP address. There are still other applications which could be implemented if, in addition to device location information, a reliable device identifier such as a MAC address corresponding to a device using an IP address could be determined. Such device identification information when combined with location information could be used to provide services which require both device and location information, e.g., services such as locating stolen computer devices.

[**0042**] In view of the above discussion, it should be apparent that there is a need for a reliable way of determining physical location information corresponding to a device using an IP address which may have been dynamically assigned, e.g., assigned to the device for a limited time period. There is also a need for a wide range of security applications and methods assuming device location information can be determined in a reliable manner. There is also a need for various applications which require both reliable device identifier and location information.

SUMMARY OF THE INVENTION

[**0043**] Methods and apparatus for detecting fraudulent attempts to obtain an IP address are described. Methods and apparatus for providing security, screening and location verification services are also described. Such methods may use location information corresponding to an IP address which is obtained in accordance with various features of the invention.

[**0044**] In accordance with some features of the present invention, attempts to obtain IP addresses by faking a MAC address in a data portion of an IP address request message are quickly detected.

[**0045**] In accordance with the present invention, in embodiments where IP address assignment sessions are snooped, ARP is disabled in edge routers. In such embodiments, DHCP sessions are snooped by the edge router. The edge router populates the address resolution table using the MAC and IP addresses obtained from the snooped DHCP session. IP address lease time information obtained from snooping the DHCP session is used to control aging of the information in the address resolution table, e.g., entries are deleted when their lease time expires. Since the address resolution table is generated by snooping DHCP sessions, faked MAC addresses used to obtain IP addresses will be entered into the address resolution table. The faked MAC address will not match any of the MAC addresses included in Layer 2 forwarding table since the Layer 2 forwarding table is generated from the true MAC addresses obtained from frame headers.

[**0046**] When an address resolution table look-up operation results in a MAC addresses which is not found in the Layer 2 forwarding table, the corresponding IP packet is dropped by the edge router. As a result, devices which obtain IP addresses using fake MAC addresses are denied the receipt of packets directed to the IP address obtained using the fake MAC address.

[**0047**] As an enhanced security feature, before initiating a DHCP session, the edge router, in some embodiments, compares the MAC address in the body of an IP address assignment request message to the MAC address in the header portion of the frame including the request message. If there is a miss-match between the MAC in the header and the body of the frame, a fraudulent attempt at obtaining an IP address is declared and the appropriate security measures taken, e.g., the request is not forwarded to the DHCP server and security personnel are notified of the fraud.

[**0048**] Other security features of the invention relating to security screening, access control and location verification will now discussed.

[**0049**] There are a large number of applications where it would be beneficial to be able to identify the physical location and/or a physical device using an IP address at any given time. The methods and apparatus of the present invention are well suited to such applications.

[**0050**] The present invention is directed to methods and apparatus for determining, in a reliable manner, a port,

physical location and/or device identifier associated with a device using an IP address and for using such information, e.g., to support one or more security applications. IP addresses which can be used in conjunction with the method of the invention may be dynamically assigned to a device by a server for a particular time period, e.g., least time, after which it may be assigned to another device.

[0051] In accordance with one embodiment of the present invention, the IP service provider maintains a table associating particular edge router ports with physical locations serviced by those ports. In the case where an identified port of an edge router is connected to a wired LAN or wireless LAN limited to a small geographic region, e.g., a single office, residence, or other known physical location, the identified port can be correlated to the physical location to which it is connected, e.g., through a simple look-up table operation. This is similar to associating a particular POTS telephone line to a specific business location or residence. Since the port connection is controlled by the IP network service provider, the location information associated with the port connection will tend to be relatively reliable and difficult to falsify.

[0052] Reliable device identification information, e.g., MAC address information, can be retrieved in accordance with the invention in addition to location information. In various embodiments, a MAC address of a device using a particular IP address and, optionally, IP address lease time information is determined from the edge router through which the device connects to the IP network. Alternatively, MAC address information is obtained from a server, e.g., DHCP server responsible for IP address assignments, which includes information associating IP addresses with MAC addresses. This information, which is generally reliable particularly when obtained from the edge router, is used in various embodiments along with physical location information to provide a variety of security related services.

[0053] Exemplary applications/services in which the invention may be used include limiting access to a service via an IP network to devices located at a particular physical location. This may be for licensing or other reasons, e.g., to reduce the risk of an unauthorized user getting access to a system using stolen passwords and/or account information. For example, a company may wish to limit an employee's, e.g., manager's, ability to access a corporate network to a manager's home residence. A bank may wish to limit, for security reasons, an Internet banking customer's ability to conduct certain transactions to transactions initiated from the customer's residence. An even more important application may be for screening/authorizing access to a pay service such as a Video-On-Demand (VOD) service.

[0054] From a service providers perspective, it is beneficial if a service provider can provide a service to customers at particular locations without having to require special security procedures on the customer's part, special user device software, encryption keys or other special device identifiers. By authorizing locations as opposed to devices, many services can be provided without the complexities of activating/registering a particular device for use with a service prior to use. The location based service authorization process of the invention provides a much more customer friendly approach to providing services than current device specific security systems, e.g., satellite systems, where specific receivers must be registered for use and activated by being programmed with a device specific encryption key.

[0055] In accordance with one embodiment of the present invention, screening of attempts to obtain a service, e.g., video-on-demand, music or other type of subscription or pay service is provided based on a determination of the location of the requesting device as determined from the IP address being used and/or from the edge router port through which the service is being requested. Screening based on edge router device location information, e.g., edge router port information or information derived from an edge router port identifier such as physical location information associated with an edge router port, can be performed in the IP network, e.g., in the edge router or in front of a service provider's server. This provides the IP network provide the opportunity to collect revenue from a service provider for the security service while removing the burden of providing screening service requests and/or authenticating user devices from the end service provider. This allows the service provider to focus on providing the service in which it specializes without the need to address security/authorization concerns which are handled by the IP network service provider in accordance with the invention. While described as being implemented in front of the particular service provider's server, the screening/authorization function can, and in various embodiments is, incorporated into the end service provider's server with the necessary edge router and port or location information being supplied in accordance with the methods of the present invention.

[0056] In addition to location based authorization/screening applications, the methods of the present invention are applicable to a wide range of other security and/or law enforcement applications. In the case of one law enforcement application, a parole supervisor or automated system is used to check on the location status of parolees who contact the supervisor/automated system to make sure that the monitored parolee is initiating the IP based communication from a particular physical location, e.g., the parolee's home where he/she is supposed to be at some specific time, e.g., each night. The same system can be used to check that a security guard checks in at scheduled times from various pre-selected locations while, e.g., making periodic rounds a site being guarded.

[0057] The methods of the present invention can also be used to identify the physical location of a hacker based on the hacker's IP address and/or to locate the physical location of a stolen item, e.g., notebook computer with a modem or network card having a pre-assigned MAC address, which uses an IP address to communicate over an IP based network. In one stolen goods location determination embodiment, MAC addresses of devices are compared to a list of stolen MAC addresses, e.g., when a DHCP server is contacted for IP address assignment purposes. If a match is determined between a MAC address of a stolen device and a device which is in use, the location of the device is determined and law enforcement and/or the owner of the stolen device is notified.

[0058] In terms of providing services, e.g., music over IP services, VOD services, etc., it can be desirable to license a particular physical site, e.g., home location, but not others. In such a case, it might to desirable to allow any device at the particular licensed location, e.g., a customer residence, to

obtain the licensed service while blocking attempts from others to gain access to the service from other unlicensed locations, e.g., other houses.

[0059] Numerous additional embodiments, features and applications for the methods and apparatus of the present invention are discussed in the detailed description that follows.

BRIEF DESCRIPTION OF THE DRAWINGS

[0060] **FIG. 1** illustrates an Ethernet frame.

[0061] **FIG. 2** is a simplified Internet diagram.

[0062] **FIG. 3** illustrates the 32 bit IP addressing scheme used for Internet addresses.

[0063] **FIG. 4** illustrates the components of a 32 bit Internet address having the illustrated subnet mask.

[0064] **FIG. 5** illustrates a communications system implemented in accordance with the invention.

[0065] **FIG. 6** illustrates an edge router implemented in accordance with the invention.

[0066] FIGS. **7-9** illustrate various tables included in the edge router of **FIG. 6**.

[0067] **FIG. 10** illustrates a DHCP server responsible for dynamically assigning IP addresses and for storing information relating to said addresses in accordance with the present invention.

[0068] **FIG. 11** illustrates a location and customer information server (LCIS) implemented in accordance with the invention.

[0069] **FIG. 12** illustrates a router and port number to customer (RPC) information database implemented in accordance with the invention.

[0070] **FIG. 13** illustrates a routine for providing customer information corresponding to an IP address in response to information requests.

[0071] **FIG. 14** illustrates a frame/packet processing and forwarding routine implemented, e.g., by an edge router, in accordance with the present invention.

[0072] **FIG. 15** illustrates the steps of a DHCP snooping subroutine of the present invention which may be used in conjunction with the routine shown in **FIG. 14**.

[0073] **FIG. 16** illustrates a conventional frame that may be transmitted by a device on an Ethernet to request an IP address assignment.

[0074] **FIG. 17** illustrates an exemplary security server, implemented in accordance with the invention, which operates as an access control router.

[0075] **FIG. 18** illustrates an exemplary subscriber/service information database which may be sued by the security server of **FIG. 17**.

[0076] **FIGS. 19 and 20** illustrate the steps of an exemplary service authorization/security routine which may be implemented by the security server of **FIG. 17**.

[0077] **FIG. 21** illustrates the steps of a location verification routine which may be implemented by the server of **FIG. 17** in accordance with the invention.

DETAILED DESCRIPTION

[0078] **FIG. 5** illustrates a communication system **500** implemented in accordance with the present invention. As will be apparent from a review of **FIG. 5**, the communication system **500** has many elements which are the same as or similar to the elements of the existing Internet as shown in **FIG. 2**. Elements in **FIG. 2** and **FIG. 5** which are the same as, or similar to, one another are indicated using the same reference numbers in both figures. Such elements will not be described again in detail.

[0079] The system illustrated in **FIG. 5** includes first and second Layer 2 networks **501**, **503**, e.g., Ethernet LANs, coupled together by a Layer 3, e.g., IP based, network **505**. In addition to the IP based network **505**, the system **500** includes additional networks **530**. The additional networks include a service management network (SMN) **532** and a public switched telephone network **531**. One or more conventional (e.g., non-IP) telephone devices may be coupled to the PSTN **531**. A 911 operator center **560** which includes a 911 database **562** is shown coupled to the PSTN **531** but may be implemented as part of the PSTN. The 911 database **562** includes customer and address information associated with telephone numbers. The database **562** is accessed and used to determine a caller's location in the case of a 911 emergency call. In **FIG. 5**, for purposes of illustration, a single telephone **535**, located at a customer premise **531**, is shown coupled to the PSTN **531**. In reality many such telephone devices located at different customer premises are coupled to the PSTN **531**.

[0080] The first Layer 2 network, e.g., LAN **501**, includes host devices **208**, **210** coupled to Ethernet bus **204**. The LAN **501** is located at a first customer premise (CP) **521**. Similarly, the second Layer 2 network **503** including host devices **212**, **214** coupled to Ethernet bus **206**. The LAN **503** is located at a second CP **523**. Each CP **521**, **523**, corresponds to a single physical location, e.g., an office building or home, for which location information can be stored in the SMN **532**.

[0081] An IP based network **505** couples the first and second Layer 2 networks **501**, **503** together. The IP based network **505** includes first and second edge routers **516**, **518**, a DCHP server **520**, core routers **222**, **224**, **226**, a security server **528**, a video-on-demand (VOD) sever **571**, a MOD server **573**, banking server **575** and a soft switch (SS) **536**. The security sever **528** operates as a security and/or authorization device for VOD sever **571**, MOD server **533** and bank server **535**. As will be discussed below, it also operates as a security device with the ability to detect the use of stolen devices and report the use/location of stolen devices to the owner and/or appropriate law enforcement authorities. The sever **528** also servers as a location verification device in some embodiments. In addition to these functions the server **528** operates as a router forwarding packets between the other nodes of the network, e.g. routers R3 **222** and R6 **226**. Security server **528** is coupled to the LCIS **534** via a secure communications link. This allows the security server **528** to direct information requests to the LCIS **534** and receive information from the LCIS **534** in a secure and reliable manner.

[0082] The first and second edge routers **516**, **518** serve as the interface between the Ethernet LANs **501**, **503**, respectively, and the IP **505**. While the edge routers **516**, **518**

perform the same functions as edge routers **216**, **218** as will be discussed further below, they also include routines for responding to requests to identify a router port corresponding to an IP or MAC address supplied as part of a port information request.

[**0083**] The DHCP server **520** is responsible for dynamically assigning IP addresses while the SS **536** is responsible for interfacing between the IP network **505** and public switched telephone network (PSTN) **531**. The soft switch stores information associating IP address of telephone devices with telephone numbers. It is responsible for routing IP telephone calls between IP telephone devices over the IP network **505** and for performing the necessary protocol conversions required to bridge and route telephone calls between the IP domain and the PSTN **531**. Routing of telephone calls between the IP and PSTN domains may be required, e.g., when a telephone call between an IP device and a conventional PSTN telephone occurs.

[**0084**] To facilitate the secure exchange of customer and management information between system components, e.g., routers and servers in the system **500**, the system **500** includes a secure management network (SMN) **532**. The SMN **532**, which may be implemented using IP, is in addition to the Layer 3 network **505**.

[**0085**] As an alternative to using a separate network for the exchange of management and customer information, secure communications channels can be implemented between system components, e.g., routers and servers, using encryption and/or other virtual private networking techniques. Accordingly, customer and management information may be transmitted over separate physical communications channels or secure communications channels provided using existing communications links between network elements.

[**0086**] Various elements are incorporated into the SMN **532** including a location and customer information server (LCIS) **534** implemented in accordance with the invention. As will be discussed below, in accordance with the present invention, the LCIS **534** includes a router-port to customer information (RPC) database **537**. The RPLC database **537** includes sets of customer records created, e.g., when a customer subscribes to an IP service provider. As will be discussed below each record may include, e.g., customer premise location information, name, address and land-line telephone number information. Each customer record is correlated to an edge router and port which is assigned to be used by the customer when accessing the IP network via a LAN or other connection. The RPC database **537** may also include IP address and address lease time information corresponding to a customer. This information, in some embodiments, is populated with information obtained from an edge router and/or the DHCP server. Such information may be retrieved and stored in response to an information request including an IP address of interest (IPAOI) received from another device, e.g., security server **528**.

[**0087**] For various applications, e.g., authentication/authorization of services, servicing of 911 emergency telephone calls, the SS **536** and/or other network devices such as security server **528**, coupled to the SMN **532** may request the location and/or other customer information associated with a particular IP address of interest (IPAOI). The IPAOI may be, e.g., the IP address used to initiate a 911 call from an IP telephone or the IP source address of a packet directed to a premium service provider, e.g., VOD server **571**, MOD server **573** and/or bank server **575**. As will be discussed below, the LCIS **534** includes routines for responding to such information requests and returning relevant information to the requesting device, e.g., server.

[**0088**] **FIG. 6** illustrates an edge router **600** which may be used as any one of the edge routers **516**, **518** of the system illustrated in **FIG. 5**. As illustrated, the edge router **600** includes a CPU **602**, packet/frame forwarding engine **606**, memory **704** and I/O interface **610** which are coupled together by a bus **603**. The I/O interface **610** includes a plurality of ports used to connect the edge router **600** to various networks. Ports **1** through N are used to couple the router **600** to one or more Ethernet LANs. Ports N+1 through 2N are used to connect to elements of the IP network **505**, e.g., DHCP server **520** and router R3 **522** or R6 **526**, while Ports 2N+1 through 3N are used to couple the edge router **600** to the SMN and thus the LCIS **534** included therein.

[**0089**] The memory **604** includes an L2 forwarding table **626**, an L3 forwarding table **628**, an L2 to L3 address resolution table **624**, a frame/packet processing and forwarding routine **622**, an operating system **612**, address resolution table management routine **614**, port number information routine **618**, DHCP snooping sub-routine **630** and security routine **632**.

[**0090**] The Layer 2 forwarding table **626** includes information used for forwarding received Ethernet frames according to the MAC destination address specified in the frame's header.

[**0091**] **FIG. 7** illustrates an exemplary L2 forwarding table **626**. The table includes a plurality of entries **701**, **701'**. Each entry includes a MAC address **702**, **702'** and a port number **704**, **704'**. Under direction of the forwarding routine **622**, frames received by the edge router having a MAC address listed in the L2 forwarding table are output using the port **704**, **704'** corresponding to the destination MAC address. In this manner Ethernet frames are forwarded in the Layer 2 domain based on MAC destination addresses.

[**0092**] The Layer 3 (L3) forwarding table **628** is used by the router **600** to forward IP packets in the IP domain. As illustrated in **FIG. 8**, the L3 forwarding table includes a plurality of entries **801**, **801'**. Each entry includes an IP address **802**, **802'**, a port number **804**, **804'** and aging information **806**, **806'**. The aging information is used to determine when an entry **801**, **801'** should be deleted from L3 forwarding table as part of a table maintenance operation. Under direction of the forwarding routine **622**, IP packets received by the edge router **600** having a MAC address listed in the L2 forwarding table are output using the port **804**, **804'** corresponding to the destination IP address. In this manner IP packets are forwarded in the Layer 3 domain based on IP addresses.

[**0093**] The L2 to L3 address resolution table **624**, shown in **FIG. 9**, is used for converting between Layer 2, e.g., MAC, addresses and Layer 3, e.g., IP, addresses. The L2 to L3 address resolution table **624** includes a plurality of entries **901**, **901'**. Each entry includes a MAC address **902**, **902'**, an IP address **904**, **904'** and aging information **906**, **906'**. As in the case of the L3 forwarding table **628**, the aging information **906**, **906'** is used for table maintenance purposes.

[0094] When an IP packet is received which has a destination address not found in the L3 forwarding table **628**, the forwarding routine **622** compares the received IP destination address to the entries in the L2 to L3 resolution table **624**. If the IP address is listed in the table **624**, the MAC address **902** or **902'** corresponding to the received destination IP address **904** or **904'**, respectively, is retrieved from the L2 to L3 address resolution table. The MAC address is then used in a L2 forwarding table look-up operation. Using the MAC address as an index to the L2 forwarding table, an output port to be used for forwarding the information included in the received IP packet is determined. As part of the forwarding operation, content from the received IP packet is placed into the payload of an Ethernet frame and then transmitted to the appropriate Ethernet LAN via the port identified in the L2 forwarding table. In this manner, IP packets received from the IP network can be transmitted to devices over the Ethernet LAN coupled to the edge router **600**.

[0095] In accordance with one feature of the invention, as an alternative to using address resolution protocol (ARP), the DHCP monitoring routine **611** snoops DCHP sessions between devices on the Layer 2 network, e.g., devices **208**, **210** and the DHCP server **220**. In this manner, the monitoring routine **611** obtains information on the assignment of IP addresses to devices and the release of IP address by devices. This information is conveyed to the address resolution table management routine **614** which updates the layer 2 to layer 2 (L2 to L3) address resolution table **624**.

[0096] Address resolution table management routine **614** is responsible for removing, e.g., deleting, entries from the L2 to L3 address resolution table **624** and/or L3 forwarding table, after an entry has aged for a preselected period of time as indicated from the aging information stored for each entry. Alternatively, in the case where DCHP sessions are snooped in accordance with one feature of the invention, entries are deleted from tables **624** and **628** when the IP lease time expires, a device releases an IP address, or a device fails to respond to a DHCP status inquiry. Thus, in such an embodiment, IP address entries are added to and deleted from tables **624**, **628** based on information obtained from snooping communications between host devices on a layer 2 LAN coupled to the edge router **600** and the DHCP server **220**.

[0097] Port number information routine **618** responds to port number information requests received by the edge router **600** by returning the port number corresponding to an IP address or MAC address received in a port number information request.

[0098] The routine **618** first determines whether an IP or MAC address has been received in a port number information request. If the request includes a MAC address, the received MAC address is used as an index into the L2 forwarding table to determine the router port corresponding to the received address. If an IP address is received as part of a port number information request, the IP address is first used as an index as part of a look-up into the L2 to L3 address resolution table **624**. In this manner the MAC address corresponding to the received IP address is determined from the table **624**. Once the MAC address is determined from table **624** it is used to consult the L2 forwarding table **626**. In this manner, the router port corresponding to the MAC address is determined.

[0099] The router port number determined by port number information routine **618** is returned to the device which sent the router **600** a port number information request. In the case of a port number information request from the LCIS **534**, the determined port number would normally be returned via the secure SMN **532** via which the request was received by the edge router **600**.

[0100] **FIG. 10** illustrates a DHCP server **520** implemented in accordance with the present invention. As illustrated, the DHCP server **520** includes a CPU **1002**, I/O interface **1004** and memory **1006** which are coupled together by bus **1003**. The memory **1006** includes an IP address allocation and management routine **1010**, IP to edge router and optionally MAC address look-up routine **1012**, a pool of available IP addresses **1009**, and an IP address lease information table **1014**. The pool of available IP addresses **1009** is a list of unused IP addresses which the DHCP server **520** is authorized to lease to requesting devices. In accordance with the invention, the table **1014** is used to manage leased IP addresses and as an IP to edge router (IP2ER) look-up table for providing information on the edge router associated with an IP address.

[0101] When a device on a LAN, e.g., device **208** on LAN **204**, needs an IP address so that it can access the IP network **505** it broadcasts an IP address assignment request. The request is detected by the edge router on the LAN, e.g. router **216**. The edge router **516** responds by acting as a proxy of the requesting device **208** and initiating a DHCP session with the DHCP server **520**.

[0102] This may be done as is known in the art using DHCP protocol. An IP address assignment request conveyed to the DHCP server **520** includes the MAC address of the requesting device. In response to an IP address assignment request, the DHCP server **520** assigns the requesting device **208** an available IP address from the pool **1009**. In addition the server **520** removes the address from the pool **1009** and creates a new entry **1016** in the IP address lease information table **1014**.

[0103] Each entry **1016**, **1016'** in the table **1014** includes the IP address assigned **1020**, **1020'**, the edge router **1022**, **1022'** acting as proxy for the requesting device, the MAC address **1024**, **1024'** of the device to which the IP address was assigned, and lease time information **1026**, **1026'**. The lease time information **1026**, **1026'** indicates the term, e.g., duration, of the IP address lease and other lease related information. One entry **1016** or **1016'** exists in the table **1014** for each IP address leased to a device by the DHCP server **520**. In the exemplary embodiment of **FIG. 10**, the table **1014** includes entries for K leased IP addresses **1620** through **1620'**.

[0104] When an IP address is assigned, i.e., leased, to a requesting device, the IP address and lease time information (indicating the duration of the lease) is communicated back to the requesting device by way of the edge router acting as the device's proxy.

[0105] Accordingly, as part of the DHCP server IP address leasing mechanism, a table **1014** associating assigned IP addresses with information identifying the edge router used by the device assigned the IP address to access the IP network **505** and the devices MAC address.

[0106] Edge router information requests, e.g., requests from the LCIS **534**, may be received by the DHCP server

520 via SMN **532**. IP to edge router look-up routine **1012** is responsible for responding to such requests by correlating an edge router to an IP address received in the information request. To determine the edge router corresponding to an information request, the look-up routine **1012** accesses the IP address lease information table **1014** using the received IP address as an index into the table. In this manner, the look-up routine **1012** retrieves the information **1022**, **1022**' identifying the edge router corresponding to the received IP address. In some embodiments, the routine **1012** also recovers from the table **1014**, the MAC address corresponding to the received IP address. The information identifying the edge router, and, optionally, the MAC address, corresponding to a received IP address is returned to the device, e.g., LCIS **534**, which sent the edge router information request to the DHCP server. In this manner, devices such as the LCIS can obtain from the DHCP server information identifying the edge router being used by a device having a specific IP address.

[**0107**] **FIG. 11** illustrates a location and customer information server (LCIS) **534** implemented in accordance with the invention. For security reasons, the LCIS **534** is implemented as part of the SMN **532**. However, it could, alternatively, be implemented as a device on the IP network **505** assuming sufficient security measures are taken, e.g., the use of a firewall and/or data encryption, to protect the server and its contents from unauthorized access and/or tampering.

[**0108**] The LCIS **534** includes a central processing unit **1152**, I/O interface **1154** and memory **1156** which are coupled together by bus **1153**. The CPU **1152** controls operation of the LCIS under direction of one or more routines stored in memory **1156**. The I/O interface **1154** couples the internal components of the LCIS **534** to external devices via the communications links of the SMN **532**. For example, in the **FIG. 5** embodiment, the LCIS **534** is coupled to the edge routers **516**, **518**, SS **536** and DHCP server **520** via communications links of the SMN **532**.

[**0109**] The memory **1156** includes an IP address to DHCP server database **1164**, and an edge router and port number to customer information (RPC) database **1162**, and an information request response routine **1160**.

[**0110**] The IP address to DHCP server database **1164**, includes information correlating IP addresses which may be assigned by DHCP servers to particular DCHP servers in the IP network. Thus, the LCIS **534** is able to determine which DHCP server **520**, out of a plurality of such servers, to contact for information regarding an IP address received as part of an information request.

[**0111**] The RPC database **1162** includes information correlating specific edge routers and ports to customer information including, e.g., physical location, name and landline telephone number information.

[**0112**] **FIG. 12** illustrates an exemplary RPLC database **1162**. As illustrated the exemplary database includes Q records one record corresponding to each of Q edge routers. Each record includes a router identifier **1252**, **1252**' and a set of entries corresponding to particular router ports. Each router port entry includes a port identifier **1254**, a location identifier **1256**, customer name information **1258** and telephone number information **1260**. The location information is the location of the customer premise, e.g., physical LAN location, from which the customer may access the IP network via the identified router and port. The phone number **1260** is the telephone number of a landline phone located at the corresponding physical location specified in the edger router/port entry. Additional customer information, e.g. billing, service subscription and level of desired privacy information, may also be included in the RPLC database **1162** for each router/port entry. The RPLC database **1162** is populated as subscribers contract with an IP service provider for IP service and is updated, e.g., periodically, to reflect changes in the customer information and/or the cancellation or modification of service.

[**0113**] The information request response routine (IRR) **1160** responds to requests for location and/or other customer information corresponding to an IP address. The IP address of interest and, optionally, the desired type of information, is included in an information request. Such information requests may come from a variety of sources, e.g., routers and/or servers implementing security routines, soft switch **536**, etc.

[**0114**] An exemplary IRR routine **1160** will now be discussed with reference to **FIG. 13**. The IRR routine **1160** begins in step **1302** where it is executed by the CPU **1152**, e.g., when the LCIS **534** is activated. Then in step **1304** the routine **1160** monitors for an information request **1306** including an IP address of interest (IPAOI). For each such detected IP address information request, operation proceeds to step **1307**.

[**0115**] In step **1307** the LCIS **534** identifies, e.g., by querying its IP address to DHCP server database **1164**, the DHCP server responsible for leasing the IPAOI to a device. Then, in step **1308**, the LCIS **534** sends a message, including the IPAOI, to the identified DHCP server requesting information, e.g., edge router and MAC address information, corresponding to the IPAOI.

[**0116**] In step **1310**, in response to the information request sent to the DHCP server, the LCIS **534** receives edge router identification information and, in some embodiments, the MAC address of the device to which the IPAOI was leased. Then in step **1312**, the LCIS **534** transmits a request to the edge router identified by the DHCP server for port information relating to the IPAOI. The port number information request transmitted to the identified edge router includes, when available, the MAC address received from the DHCP server in addition to, or instead of, the IPAOI.

[**0117**] In response to the port information request message, in step **1314**, the LCIS **534** receives from the contacted edge router, the edge router port number corresponding to the supplied IPAOI or MAC address. Then, in step **1316**, the LCIS **534** accesses the RPLC database **1162** using the router and port number corresponding to the IPAOI to retrieve therefrom the requested location and/or customer information determined to correspond to the IPAOI.

[**0118**] Once the desired information, e.g., customer name, location, telephone number is retrieved from the RPLC database, in step **1318** it is returned to the device which requested information corresponding to the IPAOI. The MAC address may also be returned to the requesting device where device identification information is desired.

[**0119**] Once the requested information corresponding to the IPAOI has been transmitted to the requesting device,

e.g., over the secure SMN **532**, processing of the received IP address information request stops in step **1320**. However, the monitoring operation of step **1304** and processing of other IP address requests will continue until the routine **1160** is terminated, e.g., by the LCIS **534** being turned off or shut down.

[**0120**] Various features and methods of the present invention designed to reduce security risks associated with attempts to obtain IP address assignments using faked MAC addresses, will now be explained with reference to **FIGS. 14 and 15**. In accordance with the present invention, attempts to obtain IP addresses by faking a MAC address in a data portion of an IP address request message are quickly detected and/or rendered of little use to the requesting device since IP packets directed to a fraudulently obtained IP address will be dropped by an edge router rather than forwarded over an Ethernet.

[**0121**] As discussed above, in accordance with the present invention, in embodiments where edge routers snoop IP address assignment sessions, ARP is disabled in edge routers. The edge router populates the address resolution table using the MAC and IP addresses obtained from the snooped DHCP session. Lease time information obtained from snooping the DHCP session is used to control aging of the information in the address resolution table, e.g., entries are deleted when their lease time expires. Since the address resolution table is generated by snooping DHCP sessions, faked MAC addresses used to obtain IP addresses will be entered into the address resolution table. The faked MAC address will not match any of the MAC addresses included in Layer 2 forwarding table since the Layer 2 forwarding table is generated from the true MAC addresses obtained from frame headers.

[**0122**] **FIG. 14** illustrates an exemplary frame/packet processing and forwarding routine **622** which implements DHCP session snooping along with various other security features of the present invention. Routine **622** may be used in an edge router, e.g., the edge router **600** such shown in **FIG. 6**.

[**0123**] The routine **622** starts in step **1401**, e.g., with the edge router **600** being powered on. As part of start up, in step **1402** the edge router initializes its Layer 2 forwarding table **626** and Layer 2 to Layer 3 address resolution table **624**. As part of the initialization process, the edge router may store an IP address corresponding to the DHCP server with which is to interact, e.g., as a proxy, for DHCP session purposes. The tables **626**, **624** are populated over time in accordance with the present invention as will be discussed below.

[**0124**] Once initialization has been completed operation proceeds to step **1404** wherein the edge router **600** operates to receive frames and/or packets and to process the received frames and/or packets depending on their content, e.g., header and/or payload information. In accordance with the invention, the edge router snoops, e.g., monitors, communications to/from a DHCP server. Accordingly, when a received packet or frame is determined to correspond to a communication to/from a DHCP server, edge router processing proceeds to the DHCP communication snooping sub-routine via step **1406**. An exemplary DHCP server subroutine **630** will now be described with reference to **FIG. 15**.

[**0125**] The DHCP snooping sub-routine starts in step **1501**, e.g., in response to being called by routine **622**. In step **1502**, the detected communication to/from a DHCP sever is monitored and analyzed to determine the type of communication and which processing path should be followed. If the communication which triggered the sub-routine **1501** corresponds to a DHCP session initiation request message, as in the case of an Ethernet frame **1300** requesting an IP address assignment, operation will proceed from step **1502** to step **1504**. In step **1504** the edge router compares the MAC address **1306** in the data portion of an IP address request message to the MAC address **1302** in the header portion of the request message. In step **1506**, if, based on the comparison performed in step **1504**, it is determined that the MAC address in the header does not match the MAC address in the data portion of the request message, indicating an attempted fraud or error, operation proceeds to step **1508** wherein edge router security routine **632** is invoked. The security routine **632**, using the location identification techniques discussed above, determines the physical location of the perpetrator of the fraud based on the port address through which the IP address assignment was received, notifies authorities of the attempted fraud and/or takes other actions. Processing of the fraudulent IP address assignment request stops in step **1510**, once the invoked security routine has completed the security actions to be taken. Thus, in the case where MAC address check is made in steps **15041506**, the DHCP server will not be burdened with IP address assignment requests where the MAC address in the data portion of a message is inconsistent with MAC address in the header of the Ethernet frame which includes the IP address assignment request.

[**0126**] In the case where the MAC address in the header matches the MAC address in the body of a message, operation will proceed from step **1506** to step **1522**.

[**0127**] In some embodiments, the security checks of step **1504** and **1506** are not implemented due to limited edge router processing resources. In such cases, mismatches in MAC addresses will go undetected at the edge router and processing will proceed from step **630** to step **1512** in the case of DHCP session initiation requests, even if a fraudulent MAC address is included in the data portion of a request message. However, as will be discussed below any IP address assigned based on a fraudulent MAC address will be of little use in the system of the present invention.

[**0128**] In step **1512**, the edge router transmits a DHCP session initiation request to the DHCP server with the edge router acting as a proxy for the requesting device, e.g., a device on the Layer 2 network. Operation proceeds to proxy step **1514** wherein the edge router operates as a proxy for the duration of the DCHP session which it snoops to determine information used to update its LAYER2 to Layer 3 address resolution table.

[**0129**] In substep **1516** the edge router transmits at least a portion of a received frame, e.g., frame **1300**, including an IP address assignment request and an indicated MAC address to the DHCP server **520**. The edge router then proceeds to process the information received from the DHCP server **520**. This processing proceeds along two parallel paths. In substep **1518**, the edge router relays the IP address assigned by the DHCP server **520** in response to the assignment request along with lease time information and a corresponding address mask to the client device on the Layer 2 network which initiated the IP address assignment

request. In parallel, the edge router a new Layer 2 to Layer 3 address table entry is generated. In step **1524** the MAC address portion of the new address table entry is populated using the MAC address obtained from snooping the DHCP session. If this address was faked and went undetected, the entry will thus include the faked MAC address. The IP address portion of the new entry is then populated in substep **1526** with the IP address assigned by the DHCP server **520** which was learned by snooping the DHCP session. IP address aging information and possibly other information learned by snooping the DHCP session is used in substep **1528** to populate aging and other fields of the new table entry thereby forming a complete Layer 2 to Layer 3 table entry which can be used for address resolution purposes, e.g., in the delivery of received IP packets over the Ethernet as part of an Ethernet frame. With the completion of substeps **1518** and **1528**, e.g., at the end of a DHCP session corresponding to an IP address assignment operation, processing associated with the initiated DHCP session stops in step **1520**. Thus, in accordance with the present invention, the L2 to L3 address resolution table is generated by snooping, e.g., monitoring, communications between devices on the Ethernet and the DHCP server **520** responsible for assigning IP addresses. ARP is NOT used when using this feature of the present invention. Note that since the MAC address entered in the L2 to L3 address resolution table was obtained from snooping the DHCP session, if it was faked, the MAC address will not match the MAC address loaded into the edge routers L2 forwarding table which was obtained from an Ethernet frame header. This will result in packets directed to the IP address assigned using the fake MAC address being dropped since the faked MAC address will not match any entries is the L2 forwarding table and packets corresponding to unmatched MAC addresses are dropped in accordance with the invention for security reasons.

[**0130**] In addition to monitoring for messages to initiate DHCP sessions for purposes of obtaining IP address assignments, the edge router will detect IP address release messages and DHCP client status queries all of which will result in the DHCP snooping sub-routine being called. In this manner, an accurate L2 to L3 address resolution table can be maintained and updated by snooping communications to/from the DHCP server **520**.

[**0131**] If in step **1502** the detected communication is determined to be an IP address release message, e.g., transmitted to the DHCP server, operation will proceed to step **1532**. In step **1532** the entry in the edge router's L2 to L3 address resolution table corresponding to the IP address message being released is deleted. If however, in step **1502**, a DHCP client status query is detected, e.g., a message sent to determine if a client with a particular IP address is still active, operation proceeds from to step **1538**. In step **1538** the edge router monitors for a response to the query message which would indicate that the client assigned the IP address specified in the status query was still active. If, in step **1540**, it is determined that an expected response to the status query was not detected, operation proceeds to step **1542** and the entry corresponding to the IP address associated with the status query is removed from the L2 to L3 address resolution table. In this manner, IP addresses which are no longer being used by a device and are likely to be reassigned to another device due to a failure to respond to a status query from the DHCP server **520**, will be removed in a timely fashion from the edge routers L2 to L3 address resolution table **624**.

[**0132**] If in step **1540** it was determined that a response was received in a timely manner to a status query, processing performed in response to the query message will be stopped with the content of the L2 to L3 table **624** being left unchanged since the IP address associated with the status query remains in use.

[**0133**] In addition to updating the L2 to L3 address resolution table **624** based on information snooped from communications between and a device on the L2 network and the DHCP server, **520** entries will be removed when the lease time associated with an IP address expires. In this manner, entries for addresses whose lease times have expired will be removed from the table insuring accurate routing. As will be apparent from the remaining discussion of **FIG. 14**, when an address resolution table look-up operation results in a MAC addresses which is not found in the Layer 2 forwarding table **626**, the corresponding IP packet is dropped by the edge router. As a result, devices which obtain IP addresses using fake MAC addresses are denied the receipt of packets directed to the IP address obtained using the fake MAC address.

[**0134**] Having discussed the DHCP snooping subroutine, we will now return to a discussion of the frame/packet processing and forwarding routine **622** shown in **FIG. 14**. If in step **1404**, an IP packet for the L2 network is received, the L2 to L3 address resolution table **624** is consulted. If the L3 address is not found in the table **624**, it is dropped the packet is dropped in step **1410**. If the L3 address is found in the table, the IP packet is converted to a frame and the L2 address corresponding to the received L3 address is used. Then, in step **1415**, the L2 forwarding table **626** is consulted to determine the port on which the generated Frame should be transmitted. If in step **1415**, the L2, e.g., MAC, address for the generated frame cannot be found, the generated frame is dropped in step **1410**. This will occur in the case of faked MAC addresses since the MAC address entered in the L2 to L3 address resolution table **624** will not match the MAC addresses entered in the L2 forwarding table **626** which were obtained from frame headers. Assuming that in step **1415** the L2 address is found in the L2 forwarding table **626**, in step **1416** the generated frame is delivered via the port indicated in the L2 forwarding table **626**. Processing by the edge router **600** in response to the received IP packet then stops in step **1412**.

[**0135**] While the optional comparison of the MAC address in the body of a DHCP request to the header MAC address was described as being performed in some embodiments in the edge router **600**, the same check can be performed in the DHCP server **520** prior to assignment of an IP address. In such embodiments, before assigning an IP address to a received MAC address, the DHCP server first contacts the edge router **600** from which the IP assignment request was made and inquires if the received MAC address is included in the edge routers L2 forwarding table **626**. If the DHCP server **520** learns through this inquiry that the MAC address received in an IP address assignment request is not included in the edge routers L2 forwarding table **626**, fraud is assumed and appropriate security measures are taken, e.g., the DHCP server **520** denies the request for an IP address assignment and signals the appropriate entities of a possible attempt to breach system security.

[0136] The above described method of snooping DHCP sessions has the advantage of providing a system with reliable MAC, router/port and location information which can be associated with an IP address being used. This information, which can be returned by the LCIS **534** in response to an information request, can be used to support a wide range of applications including location based service authorization/screening for IP based pay services such as VOD services, the detection of stolen devices and their location, and to confirm that a IP message is being received from a particular location. Such services may be provided by the security server **528** of the present invention.

[0137] **FIG. 17** illustrates and exemplary security server **1700** which can be used in an IP network as a router that controls access to one or more other servers, e.g., a VOD server **571**, MOD server **573** and/or banking server **575** and also has the ability to forward packets to other routers. The security server **1700** may be used as the security server **528** shown in **FIG. 5**.

[0138] The server **1700** includes a packet/frame forwarding engine **1706**, an I/O interface **1710**, memory **1704** and a CPU **1702** which are coupled together by a bus **1703**. The packet/frame forwarding engine **1706** is used to process and forward packets according to routing information stored in memory **1704**. I/O interface **1710** is used for coupling the server **1700** to other network devices including other IP network elements e.g., routers, optionally to an Ethernet, the SMN **532** including the LCIS **534** and additional networks, e.g., the PSTN **531**, through soft switch **536**, in some embodiments. The memory **1704** includes various routines including a service authorization/security routine **1712**, security subroutine **1750**, location verification routine **1752**, frame/packet processing and forwarding routine **1722**. The memory also includes a service/ subscriber information database **1714** ad a stolen device information database **1730**. The information in these databases **1714**, **1730** may be used by the routines when they are executed by the CPU **1702**. The various routines **1712**, **1750**, **1722**, **1714** when executed by CPU **1702** control operation of the security server **1700** including packet/frame forwarding and other operations. While frame/packet processing and forwarding routine **1722** controls packet/frame routing and forwarding using routing and forwarding tables stored in memory **1704**, such as those shown in **FIG. 6**, the service authorization/security routine **1712** operates to prevent forwarding of packets corresponding to a location which is not authorized to receive a service to which a packet is directed, e.g., as indicated by the packets destination address. An exemplary service authorization/security routine **1712** will be discussed in detail below.

[0139] Location verification routine **1752** is used to provide a location verification and reporting service. The service may be used to monitor individual's on parole, to monitor security guards as they make their rounds, etc. As will be discussed below, the location verification routine **1752** is used to process IP packets with an IP destination address corresponding to a location monitoring service and to verify that the received packet was sent from the expected physical location. In the event that the packet was sent from a location other than the expected location the routine **1752** provides a notification of the unexpected source location and indicates the location from which the packet actually originated. This facilitates retrieval and documenting of the location of individuals, e.g., parolees, as they periodically check in with the security server **1700** as part of their parole obligations.

[0140] In cases where device identification information, e.g., a MAC address, is returned to the service authorization/ security routine **1712**, the device identification information is compared to information in a database of stolen device information **1730**. The database **1730** is periodically updated by device owners and/or law enforcement authorities (LEAs), e.g., the police. The stolen device information database **1730** includes a plurality of records **1731**, **1737**. Each record corresponds to one of a plurality of stolen devices SDl through SDN. Each record **1731**, **1737** includes device identification information, e.g., a MAC address **1732**, **1732'**, owner information **1734**, **1734'** and law enforcement authority (LEA) information **1736**, **1736'**. Ownership information **1734** may include, e.g., the name, physical address (building address) and E-mail address of the owner of the stolen device. LEA information **1736** may include, e.g., the name of the law enforcement authority (LEA) which listed the item stolen or which should be contacted in the event the stolen device is detected or located, the physical address of the LEA to be contacted and the LEA's E-mail address. The owner and/or LEA E-mail address information is used, in various embodiments, to send E-mail or another notification, e.g., an instant message notification to the owner and/or LEA corresponding to a stolen device when the device is detected. The notification information will normally include information, including the physical location of the stolen device as determined from the LCIS **534** as well as information on the time actual or attempted use of the stolen device was detected.

[0141] **FIG. 18** illustrates an exemplary service subscriber information database **1714** which may be used by the security server **1700**. The service subscriber information database includes a plurality of rows, **1820**, **1822**, **1824**, **1825**, each row represents a separate information record corresponding to a different service subscriber or individual. Each row is divided into a plurality of columns which store various type of information.

[0142] The first column **1802** stores the name of the party or individual to which the record corresponds. In the case of a subscription service, the name in column **1802** will normally correspond to a service subscriber. In the case of a location monitoring service, the name in column **1802** will normally correspond to the name of the individual, e.g., parolee, who's location is being check based on received messages, e.g., IP packets. The second column **1804** includes physical location information, e.g., the location of the subscriber or the listed residence of the person who's location is being monitored. The third column **1806** includes service information. This normally includes an identifier (e.g., VOD, MOD, LOC VER) of the service or services to be provided to the service subscriber or individual to which the record corresponds. Exemplary services include Video on Demand (VOD), music on demand (MOD) and location verification (LOC VER). The service information **1806** normally also includes an IP address for each one of the services to be supported. This IP address will normally correspond to the address of the service provider's server or, in the case of a location verification service, an IP address to which the monitored individual is to send messages at pre-selected times. Rows **1820**, **1822** and **1824** correspond

to different VOD service subscribers. Row **1822** corresponds to a subscriber who subscribes to a MOD service in addition to a VOD service. ROW **1823** corresponds to a subscriber who uses an at home banking service. Row **1825** corresponds to an individual who is subject to location monitoring as indicated by the LOC VER indicator in the service information column **1806**. Location verification service information may include, information on the location from which the monitored individual is to initiate contact and the times the security server is to be contacted to enable location monitoring. The information **1806** may, and often does in the case of a location verification service, also include information on the format of a location verification report to be generated and an E-mail or other address where the monitoring report or alerts regarding location discrepancies or failures to receive messages at anticipated times are to be sent.

[**0143**] A match between a IP packet destination address and an IP address corresponding to a particular service listed in column **1806** is normally interpreted as an attempt to obtain the service to which the IP packet destination address corresponds.

[**0144**] The fourth through eighth columns **1808**, **1810**, **1812**, **1814** include information which is returned by the LCIS **534** in response to an information request concerning an IPAOI which is normally the source address of a received IP packet. Column **1808** includes router and port information which identifies the port of the edge router from which the packet including the IPAOI was received. Column **1810** includes the MAC address of the device associated with the IP address listed in column **1812**. Column **1812** lists the IP address for which information was returned from the LCIS **534**, e.g., the IPAOI, while column **1814** includes IP address lease time information for the IP address of the same row. The information in columns **1808**, **1810**, **1812**, **1814** will be deleted when the IP address lease time information in column **1814** indicates that the lease for the IP address stored in column **1812** has expired. In this manner, the information in the information database **1714** is kept timely. In some embodiments, the DHCP server **520** sends information to the security server **528** when an IP address lease expires prematurely, e.g., due to a failure of a device using an IP address to respond to a status inquiry from the DHCP server **520**. This allows the information database **1714** to be updated to reflect that the IP address is no longer associated with the particular device identified by the MAC in column **1810** in an extremely timely manner. This updating normally involves deleting the information in columns **1808-1814** corresponding to the IP address whose lease expired prematurely.

[**0145**] An exemplary service authorization/security routine **1712** shown in **FIG. 19** will now be described. The routine starts in step **1902** when it is executed, e.g., when the security server **528** is powered up. Next, in step **1906** the routine **1712** monitors for received packets **1904** having a packet destination address corresponding to a service which is to be provided. This may be done by comparing the destination address of a received packet to IP service addresses listed in service information column **1806** to determine if there is a match. For each packet having a destination address matching that of a service to be provided, operation proceeds to step **1911**. In step **1911**, a check is made to determine if the packet destination address corresponds to a location verification service. If it does, operation proceeds to step **1913** which causes processing to GOTO location verification routine step **2104** so that the service can be provided. The received IP packet corresponding to the location verification service, e.g., a packet corresponding to a message used to report the location of an individual who's location is being monitored is also passed to the location verification routine **1752** as part of GOTO step **1913**. An exemplary location verification routine **1752** will be discussed below with regard to **FIG. 21**.

[**0146**] If in step **1911**, it is determined that the destination address of the received IP packet does not correspond to a location verification service, operation proceeds to step **1908**. In step **1908**, a determination is made as to whether or not the packet source IP address is already listed in the subscriber service information database, e.g., in the sixth column **1812**, indicating that a location check was already performed on the IP address and that the lease time of the IP address has not expired.

[**0147**] If in step **1908** it is determined that the packets source IP address is not in the subscriber service information database **1714**, operation proceeds to step **1916** wherein an information request message including the packet's source IP address is sent to the LCIS **534** in order to obtain location and other information, e.g., a MAC address and IP address lease time information, from the LCIS **534**. Next, in step **1918**, the location and/or additional information is received from the LCIS **534** in response to the information request message sent in step **1916**. Then, in step **1920**, assuming a MAC address was returned with the location information received in step **1918**, a check is made to determine if the returned MAC address or another device identifier returned by the LCIS **534** corresponds to a stolen device MAC address or other stole device identifier listed in the database of stolen device information **1730**.

[**0148**] If the MAC address or other identifier corresponds to a stolen device entry, operation proceeds to step **2011** of **FIG. 20** via connecting node **1922**. In step **2011**, the packet corresponding to the stolen device is dropped to prevent forwarding to the IP packet's destination address. Then, in step **2016** law enforcement and owner information corresponding to the stolen device is retrieved from the stolen device information database. The retrieved law enforcement and ownership information is used in steps **2020**, **2018**, respectively, to generate law enforcement and owner notification messages. These messages may include, e.g., along with information obtained from the IP packet, location and other information received from the LCIS **534**. The generated messages are transmitted in step **2022**. Thanks to the inclusion of location information, the party, e.g., owner or law enforcement authority, receiving the message may be informed not only that someone is attempting to use the stolen device at a particular time but also the actual physical location of the stolen device making retrieval possible. After transmission of the stolen device notification messages processing corresponding to the particular IP packet received from the stolen device stops in step **2024**.

[**0149**] Referring once again to **FIG. 19**, if in step **1920**, the MAC address or other device identifier returned by the LCIS **534** was determined not to correspond to a stolen device, operation proceeds to step **1928** wherein a determination is made as to whether the returned information

corresponds to one of the customer records included in subscriber service information database **1714**. This determination may be made by comparing, e.g., name, physical location and/or router and port information to the stored information included in the subscriber service information database **1714** to identify a match between the retuned information and the information in an existing customer record. If in step **1928**, no corresponding subscriber record is found, the received IP packet is considered to correspond to a hacking attempt, e.g., an attempt to get access to a service without being a subscriber, and operation proceeds via connecting node **1926** to step **2012** of **FIG. 20**.

[**0150**] In step **2012** the IP packet which has been determined to correspond to a hacking attempt is dropped without being forwarded to the service provider to which it was directed thereby preventing the service provider, e.g., banking server **575**, VOD server **571**, or MOD server **572**, from having to respond. Then in steps **2014** and **2012** messages notifying law enforcement and the service provider of the unauthorized access attempt are generated. The messages are transmitted in step **2022** allowing the appropriate authorities to take action. The generated messages include location and/or other information obtained from the LCIS **534** in addition to IP address and other information from the dropped packet making tracking of the hacking attempt to a particular physical location and/or device possible. Processing relating to the IP packet corresponding to a hacking attempt stops in step **2024**.

[**0151**] Referring once again to step **1928** of **FIG. 19**, assuming the information received from the LCIS **534** is determined to correspond to a subscriber record included in the information database **1714**, operation proceeds to step **1932** wherein the MAC, IP address and IP address lease time information included in the corresponding customer record is updated to reflect this information which was obtained from the LCIS **534**. Once the customer record is updated operation proceeds to step **1910**. Operation would have proceeded directly from step **1908** to **1910** if the source IP address in the packet was determined in step **1908** to already be in the authorized user information database **1714**.

[**0152**] In step **1910** a determination is made as to whether the customer record corresponding to the IP packet's source address, e.g., the record having the IP source address in column **1812**, indicates the subscriber is authorized to receive the service corresponding to the packet destination address. This check can be done by determining the services to which the corresponding record indicates the subscriber is entitled to receive, e.g., by comparing the packet destination address to the IP addresses of the IP servers which provide the various services to which the user subscribes. The IP server addresses may be obtained from the service information included in column **1804** of the subscriber service information database **1714**.

[**0153**] Assuming the IP packet destination address corresponds to a service for which the source location is authorized, operation will proceed from step **1910** to step **1912** wherein the packet is forwarded to the destination address included therein. If in step **1910** it is determined that the location, e.g., customer premises, corresponding to the source of the IP packet directed to a service provider was not authorized to receive the service to which the packet is directed, operation proceeds from step **1910** to step **2012** via step **1926**. In step **2012** the packet is dropped thereby avoiding burdening an IP based service provider, e.g., VOD service provider, with unauthorized requests.

[**0154**] In the above described manner, an authorized location is able to send IP packets to the VOD server **571**, MOD server **573** or a banking server **575** with the security server **528** operating as a firewall device which uses the packet source location as the factor used to determine whether packets are passed or dropped. Thus, the methods of the present invention can be used as a location based firewall to restrict access to particular services to particular physical locations, e.g., licensed customer premises and/or business sites.

[**0155**] The location verification routine **1752** shown in **FIG. 21** will now be described in detail. This service may be used for monitoring the location of paroles. The paroles may be provided with bracelets or other devices, e.g., wireless devices, with known preprogrammed MAC addresses which can be used to contact a monitoring service, e.g., security server **528**, at pre-selected points in time. In various embodiments the bracelet provided to a monitored individual transmits a location verification message to the security server. This may be done using a leased IP address with the methods of the present invention being used to confirm, in a reliable manner, the actual physical location from which an IP location verification message is transmitted. The security server **528** uses a specific IP address to receive packets intended for the location verification server. This address may be a dedicated IP address which is preprogrammed into the bracelets as the destination address for location verification messages. Location verification messages sent to the security server **528** may include the name of the parolee, transmission time information and/or other information.

[**0156**] The location verification routine **1752**, as discussed above, can be used to verify that IP packets corresponding to a reporting message, e.g., a location reporting message, are received from an expected location and/or at an expected, e.g., pre-selected, time. It can also be used to report failures by an individual whose location is to be monitored, to contact the security server from the predetermined location at the predetermined time, e.g., a time interval between during which the monitored individual is to be at the predetermined location.

[**0157**] The location verification routine starts in step **2102** when it is first executed by the security server **528**. From step **2102** operation proceeds to steps **2122** and step **2104** which may occur in parallel. Step **2122** involves a periodic check to detect any failure to receive a location reporting message packet from an expected location at an expected time. This involves comparing stored reporting information locations and times included in column **1806** of the service information database **1714**, e.g., indicating times and locations from which location reporting messages are to be received, to information indicating the receipt of a packet corresponding to a reporting message from a particular location and the time of packet's receipt or transmission. Such information may be obtained from report information included in reports generated in step **2114** which are discussed below. In the event a failure to report receive a reporting message from a location at an expected time is detected in step **2122**, operation proceeds to step **2124** wherein a report and/or alert message indicating a reporting

violation is generated. Absent detecting a failure to report, operation will not proceed from step **2122** to step **2124** and a check will again be made in step **2122** at the next time scheduled to check for reporting failures.

[**0158**] Step **2104** involves the receipt of packet information **2003** which is passed to the location verification routine **1752**, e.g., from the service authorization/security routine in step **1913**. Operation proceeds from step **2104** to step **2106**. In step **2106**, the location verification routine **2102** generates an information request message which is sent to the LCIS **534**. The information request message includes the source address of the packet received in step **2104** as an IPAOI and seeks location and related information, e.g., MAC address corresponding to the IPAOI. Next, in step **2108**, the security server receives location and/or additional information corresponding to the IPAOI. Location information may be provided in the form of an actual physical location and/or in terms of a port of a router with which a particular physical location is associated. Additional information returned by the LCIS **534** may include, e.g., MAC address information obtained from the edge router and/or a DHCP server which leased the IPAOI, and the name of the party, e.g., individual to be monitored or service subscriber, corresponding to the physical location from which the IP address was sent.

[**0159**] Following receipt of the information from the LCIS **534**, in step **2110** a determination is made as to whether or not the location and/or name information received from the LCIS **534** corresponds to, e.g., match, physical location and/or name information listed in a record in the subscriber service information database **1714**. If corresponding record is identified in step **2110**, indicating the packet corresponds to an individual who is supposed to report in at pre-selected times, operation proceeds to step **2112** to determine if the packet was sent at an expected reporting time. This may be done by comparing expected reporting time information stored in the corresponding information record to a time, e.g., transmission or receipt time, associated with the IPPOI to determine if there is a match indicating that the packet was sent at an expected time.

[**0160**] If in step **2112** it is determined that the packet corresponding to the location reporting message was sent at an expected time, operation proceeds to step **2114** wherein a report indicating compliance with a location reporting obligation is generated. The generated report will normally indicate the name of the reporting individual, the location from which the individual reported, and the time at least one packet of a location reporting message was sent and/or received. After generation of the report, operation proceeds to step **2130** wherein the generated report is transmitted to the monitoring and/or law enforcement authority associated with the monitored individual to which the report corresponds.

[**0161**] If in step **2112** is it was determined that the packet was not received at the expected time, indicating a failure to report in a timely manner, operation proceeds to step **2124** wherein a report and/or alert message indicating a reporting violation is generated. This report/message includes similar information to that included in the report generated in step **2114** but indicates that a violation of a location reporting deadline has been detected. An alert message, e.g., an instant message, may be generated as part of step **2124** so that law enforcement and/or the monitoring authority can be notified in a timely manner and take steps to locate/recapture the non-reporting individual if necessary. Operation proceeds from step **2124** to step **2130** wherein the generated message and/or report are transmitted to the appropriate authorities.

[**0162**] If in step **2110** it is determined that the location information returned from the LCIS **534** does not match a record listed in the subscriber information database, operation proceeds to step **2116**. In step **2116** an attempt is made to determine from the MAC address the device which was used to transmit the IP packet which corresponds to a location reporting message. In the case where a monitoring device, e.g., wrist band, is assigned to a parole, the MAC address of reporting devices may be known before hand, stored in the subscriber information database. This information is used to identify a device which is reporting from a location which is different from an expected reporting location. In some cases, the IP location reporting message itself includes device identifier information and information identifying the individual being monitored which can be used for reporting purposes making MAC address based identification on a reporting individual unnecessary.

[**0163**] If, in step **2116**, it is determined that the MAC address returned by the LCIS **534** does not match that of a known location reporting device listed in the service information database **1714**, operation proceeds to step **2120** wherein a message indicating a hacking attempt is generated. Information on the location corresponding to the source of the hacking attempt, obtained from the LCIS **534**, is included in the message along with other information, e.g., the MAC address associated with the IP address which was the source of the message considered a hacking attempt. Following generation of the message, operation proceeds to step **2130** wherein the message is transmitted to the appropriate authority.

[**0164**] If in step **2116** is was determined that the MAC address returned by the LCIS **534** matched the MAC address of a known reporting device, e.g., a MAC address listed in a record of the database **1714**, operation proceeds to step **2118**. In some embodiments, where the received location reporting message includes information identifying the reporting individual or reporting device, operation proceeds from step **2110** to step **2118** without the need to obtain and check a MAC address as done in step **2116**.

[**0165**] In step **218** a message and/or report is generated indicating that a location reporting message was from the wrong location and identifying the individual corresponding to the false location reporting message as well as the actual location from which the message was sent. The individual may be determined from information included in the location reporting message to which the received packet corresponds and/or from correlating a returned MAC address to a record in the information database **1714**. Other information obtained from the LCIS **534** along with time information may be included in the message/report as well. Since the LCIS **534** returns information on the location of the source of the message, it is easy for law enforcement or other authorities to locate and apprehend the individual transmitting the false location reporting message.

[**0166**] Operation proceeds from step **2118** to step **2130** wherein the generated report and/or message are transmitted. The location verification routine **1752** continues to operate on an ongoing basis with operation proceeding from

step **2130** to step **1222** and step **2104** which may led to the generation and transmission of additional reports/messages.

[**0167**] Various additional embodiments will be apparent to those skilled in the art in view of the above description. For example, rather than return location and/or other customer information, in cases where only reliable device identification information is required, the LCIS **534** could return, e.g., the MAC address corresponding to an IPAOI, without the other customer information. Such an embodiment would be useful e.g., in cases where services were to be limited to specific physical devices.

[**0168**] The routines used to control the edge router and other devices used in the communications system of the present invention may be implemented as machine-readable instructions stored on a machine-readable medium such as memory, hard disk, or other type of memory device. Various aspects of the present invention are directed to such machine-readable medium.

[**0169**] Numerous variations on the above described methods and apparatus are possible without departing from the scope of the invention.

What is claimed is:

1. A security method for use in a communication system, the security method comprising:

receiving an IP packet including a source address and a destination address;

obtaining physical location information indicating the location of a user device which is the source of said IP packet; and

determining, as a function of the obtained physical location information, an action to be taken.

2. The security method of claim 1, wherein determining an action to be taken includes:

comparing the obtained physical location information to information listing physical locations authorized to obtain access to a service for which security is to be provided.

3. The security method of claim 2, further comprising:

dropping said packet when said comparing does not result in a match between the obtained physical location information and the information listing physical locations authorized to obtain access to the service.

4. The security method of claim 2, wherein said service is one of a banking service, video on demand service and a music on demand service.

5. The security method of claim 2, further comprising:

forwarding said packet to the destination address when said comparing results in a match between the obtained physical location information and the information listing physical locations authorized to obtain access to the service.

6. The security method of claim 1, wherein obtaining physical location information includes:

transmitting a location information request message including the source address of the received IP packet; and

receiving in response to said transmitted location information request message, information corresponding to the location of the user device.

7. The security method of claim 6, further comprising:

determining the location of the user device from edge router and port information obtained from an edge router.

8. The security method of claim 7, wherein determining the location of the user device further includes:

performing a database lookup operation to retrieve a geographic location stored in association with said edge router and port information.

9. The security method of claim 8, further comprising:

further receiving, in response to said transmitted location information request message, a device identifier associated with the source address of said IP packet; and

comparing the received device identifier to a list device identifiers corresponding to stolen devices.

10. The security method of claim 9, wherein said device identifier is a MAC address.

11. The method of claim 9, further comprising:

generating a message indicating the detection of a stolen device when said comparing step detects a match between the received device identifier and an device identifier in said list of device identifiers corresponding to stolen devices.

12. The method of claim 11, wherein said generated message includes information indicating the a geographic location where the identified stolen device is being used.

13. The method of claim 12, wherein said geographic location is a post office address.

14 The method of claim 1, further comprising:

determining if the destination address corresponds to a service for which security is to be provided; and

wherein said steps of obtaining physical location information and determining an action to be taken are performed when it is determined that said destination address corresponds to a service for which security is to be provided.

15. A security device for use in a communication system in which IP packets are transmitted, the device comprising:

means for receiving an IP packet including a source address and a destination address;

means for obtaining physical location information indicating the location of a user device which is the source of said IP packet; and

means for determining, as a function of the obtained physical location information, an action to be taken.

16. The security device of claim 15, further comprising:

a database of physical location information listing physical locations authorized to obtain access to said service; and

wherein said means for determining an action to be taken includes a comparator for comparing the obtained physical location information to information listing physical locations authorized to obtain access to a service for which security is to be provided.

17. The security device of claim 16, further comprising:

means for dropping said packet when said comparing does not result in a match between the obtained physical location information and the information listing physical locations authorized to obtain access to the service.

18. The security device of claim 2, wherein said service is one of a banking service, video on demand service and a music on demand service.

19. A stolen device detection method, the method comprising the steps of:

storing a list of device identifiers corresponding to stolen devices;

receiving an IP packet from a device including an IP address associated with said device;

using said IP address associated with said device to determine a device identifier also associated with said device;

comparing the determined device identifier to said stored list of device identifiers corresponding to stolen devices; and

determining that said IP address corresponds to a stolen device when said determined device identifier matches a device identifier in said stored list.

20. The stolen device detection method of claim 19, wherein said determined device identifier is a MAC address and wherein said stored list of device identifiers is a list of MAC addresses.

21. The stolen device detection method of claim 19, further comprising:

determining the location from which said device is used from said IP address and from information determined from a MAC address corresponding to said device.

22. The stolen device detection method of claim 21, further comprising:

generating a message indicating the location of device determined to be a stolen device, said message including the determined location form which said device is being used.

23. The stolen device detection method of claim 21, wherein said step of determining the location from which said device is used includes:

determining a router and port through which said device transmitted said IP packet; and

obtaining location information from a database associating router and port numbers with physical locations corresponding to subscriber premises.

24. The stolen device detection method of claim 23, further comprising:

storing owner contact information with said list of stolen device identifiers.

25. The stolen device detection method of claim 24, wherein said owner contact information includes an E-mail address corresponding to an owner of a stolen device.

26. The stolen device detection method of claim 23, further comprising:

storing law enforcement contact information with said list of stolen device identifiers.

27. The stolen device detection method of claim 24, wherein said law enforcement contact information includes an E-mail address corresponding to an owner of a stolen device.

28. A system for detecting stolen devices using IP addresses, the system comprising:

a stored list of device identifiers corresponding to stolen devices;

means for receiving an IP packet from a device including an IP address associated with said device;

means for determining a device identifier associated with said device from said IP address associated with said device;

means for comparing the determined device identifier to said stored list of device identifiers corresponding to stolen devices; and

means for determining that said IP address corresponds to a stolen device when said determined device identifier matches a device identifier in said stored list.

29. The system of claim 28, wherein said determined device identifier is a MAC address and wherein said stored list of device identifiers is a list of MAC addresses.

30. The system of claim 29, further comprising:

means for determining the location from which said device is used from said IP address and from information determined from a MAC address corresponding to said device.

31. The system of claim 30, further comprising:

means for generating a message indicating the location of device determined to be a stolen device, said message including the determined location form which said device is being used.

32. A location verification method, the method comprising;

receiving an IP packet including a source address;

determining from said source address the geographic location from which said IP packet was sent;

comparing the determined geographic location information to expected information indicating the expected source of an IP packet; and

determining a reporting error when said determined geographic location information does not match the expected geographic location information.

33. The location verification method of claim 32, further comprising:

transmitting a message including information on the determined reporting error to a law enforcement authority.

34. The location verification method of claim 33, further comprising:

including the determined geographic location information in said message.

35. The location verification method of claim 34, further comprising:

identifying the device transmitting said IP packet from a MAC address determined from a database associating said MAC address with said source address.

36. The location verification method of claim 35, wherein said IP packet is transmitted from a bracelet worn by a parolee and wherein said IP packet includes parolee identification information, the method further comprising:

including in said message information obtained from said IP packet identifying the parolee.

37. The location verification method of claim 33, further comprising:

determining if said IP packet was sent at a predetermined time during which a location reporting message was scheduled to be transmitted.

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