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(54) **METHOD ENABLING NETWORK ADDRESS TRANSLATION OF INCOMING SESSION INITIATION PROTOCOL CONNECTIONS BASE ON DYNAMIC HOST CONFIGURATION PROTOCOL ADDRESS ASSIGNMENTS**

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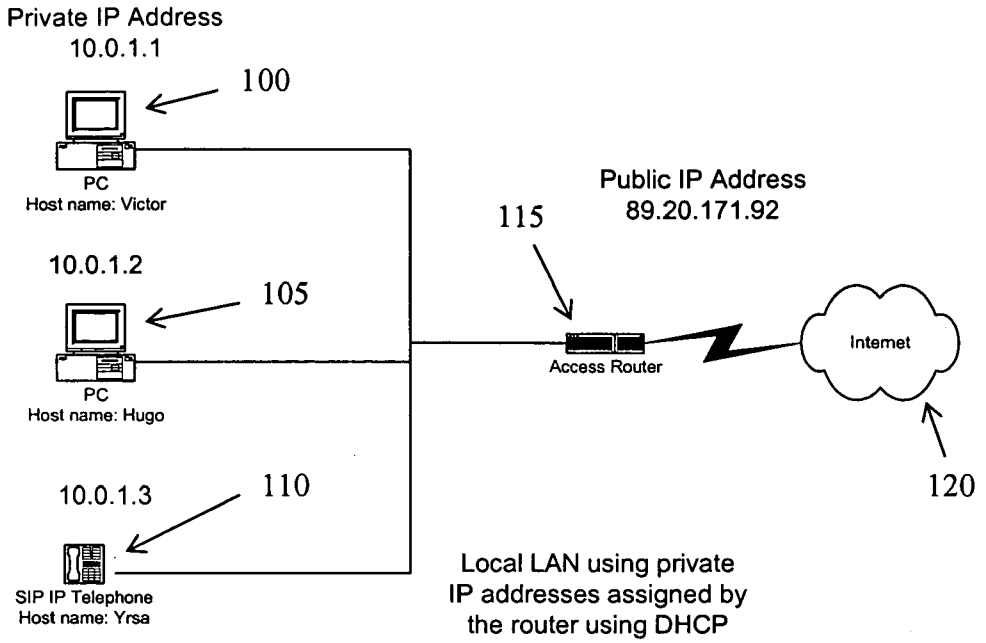
(57) **ABSTRACT**

A system for using Dynamic Host Configuration Protocol (DHCP) address assignments to determine a local destination address of a received packet in a Network Address Translation (NAT) environment. The system includes a DHCP server to assign local IP addresses to devices on a network. The system has a NAT device to execute network address translation, and a packet device to receive packets. The system further includes an addressing device to determine the local destination address of a packet received by the packet device. The addressing device uses an association table created from symbolic names of the devices on the network and the local IP addresses associated with the devices.



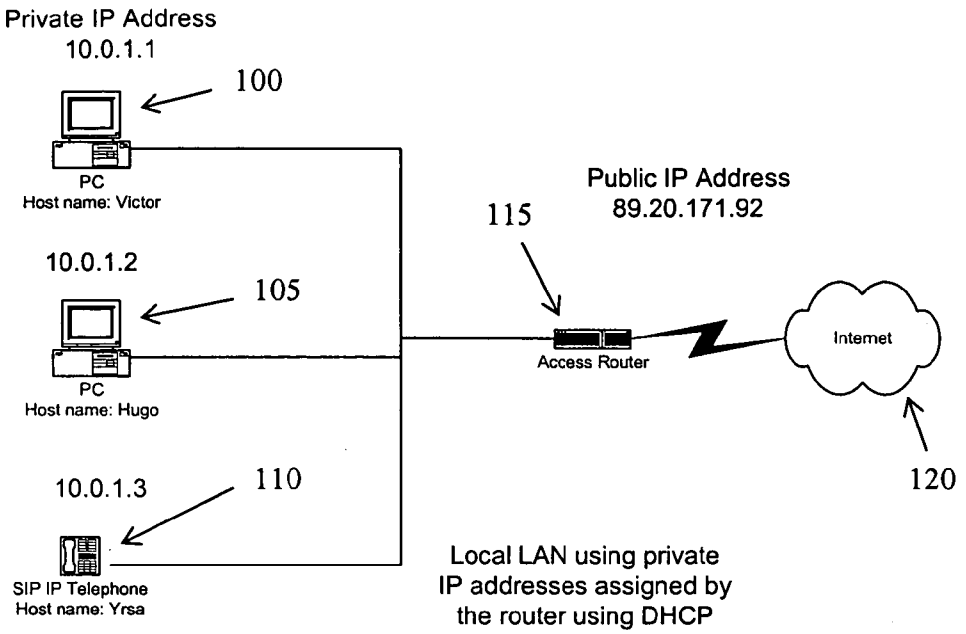

Private IP Address
10.0.1.1
100
PC
Host name: Victor
10.0.1.2
105
PC
Host name: Hugo
10.0.1.3
110
SIP IP Telephone
Host name: Yrsa
Public IP Address
89.20.171.92
115
Access Router
Internet
120
Local LAN using private
IP addresses assigned by
the router using DHCP

Figure 1

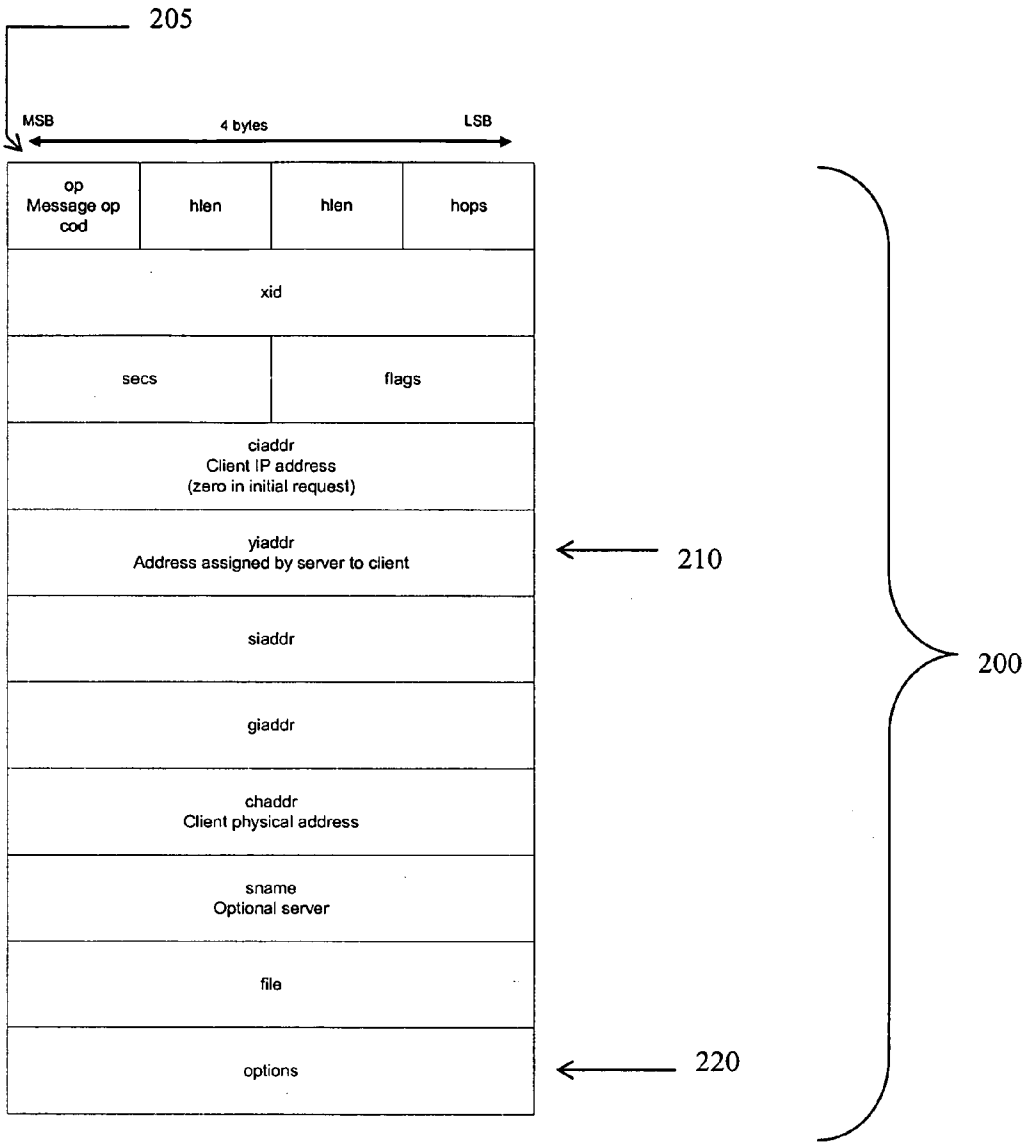

205
MSB
4 bytes
LSB
op
Message op cod
hlen
hlen
hops
xid
secs
flags
ciaddr
Client IP address
(zero in initial request)
yiaddr
Address assigned by server to client
210
siaddr
giaddr
chaddr
Client physical address
sname
Optional server
file
options
220
200

Figure 2

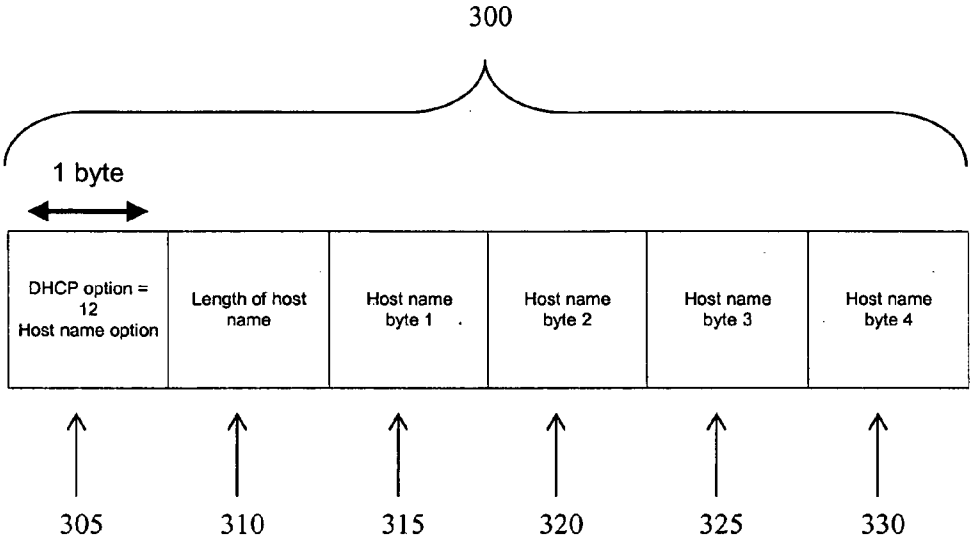

300
1 byte
DHCP option = 12 Host name option
Length of host name
Host name byte 1
Host name byte 2
Host name byte 3
Host name byte 4
305
310
315
320
325
330

Figure 3

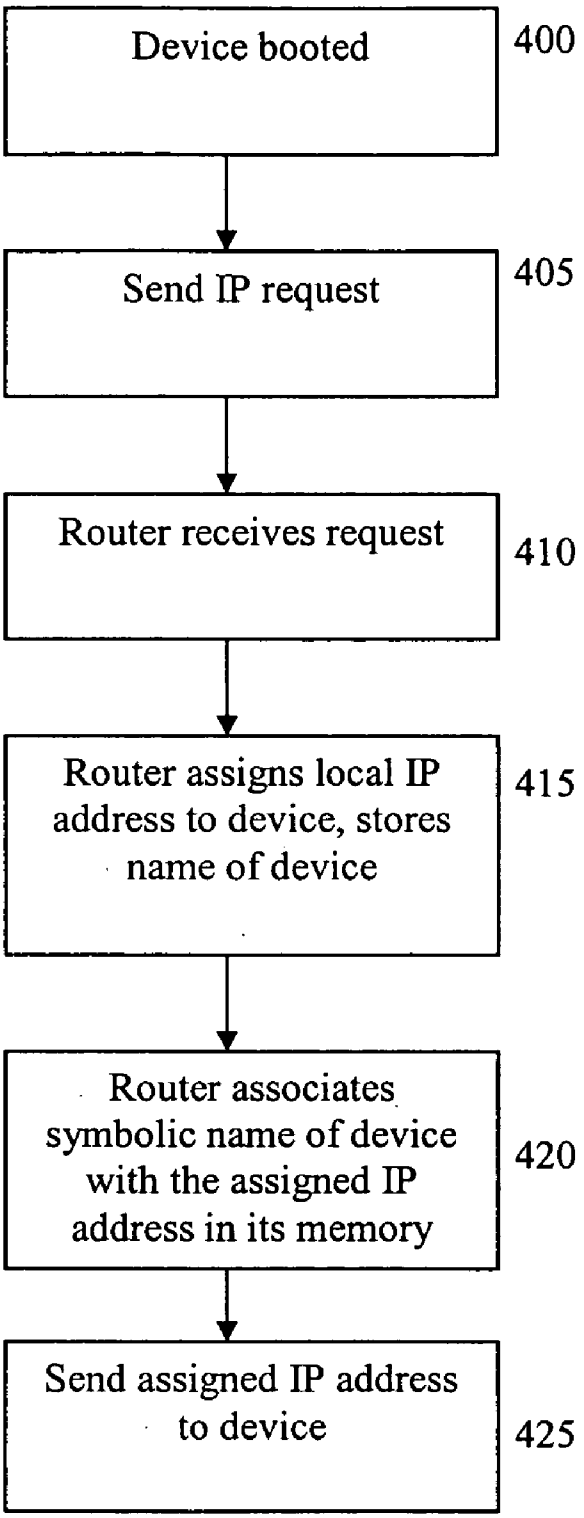
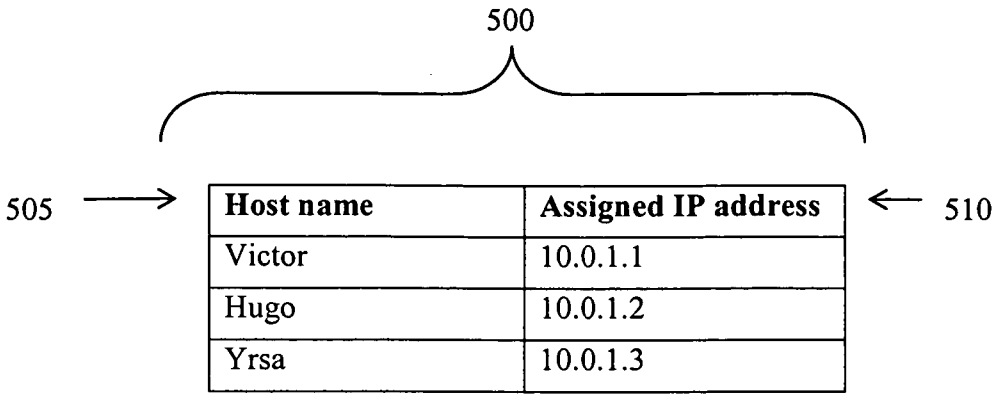

Device booted
400
Send IP request
405
Router receives request
410
Router assigns local IP address to device, stores name of device
415
Router associates symbolic name of device with the assigned IP address in its memory
420
Send assigned IP address to device
425

Figure 4



Host name	Assigned IP address
Victor	10.0.1.1
Hugo	10.0.1.2
Yrsa	10.0.1.3

Figure 5

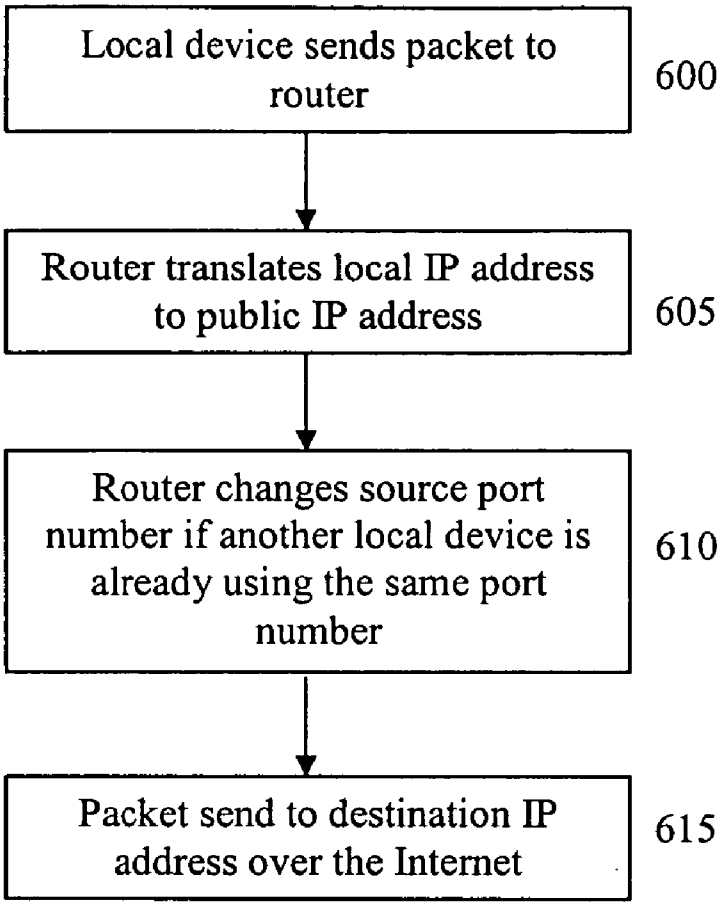

Local device sends packet to router
600
Router translates local IP address to public IP address
605
Router changes source port number if another local device is already using the same port number
610
Packet send to destination IP address over the Internet
615

Figure 6

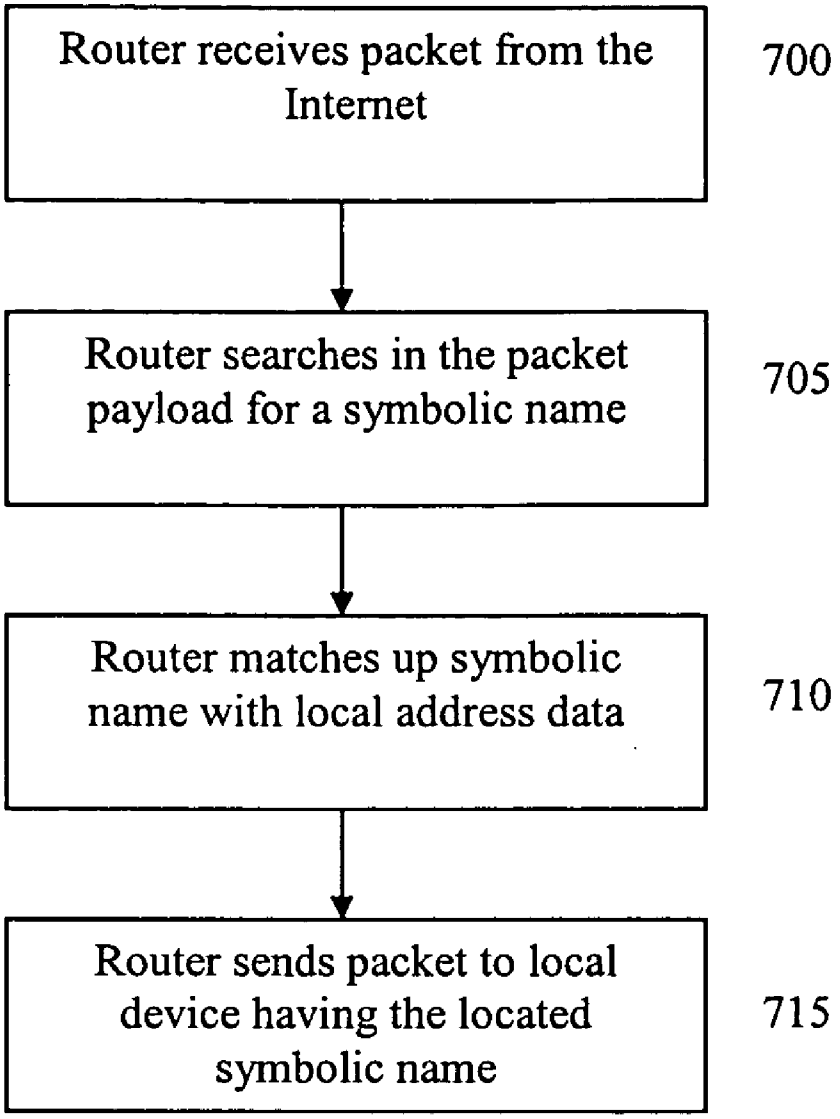

Router receives packet from the Internet
700
Router searches in the packet payload for a symbolic name
705
Router matches up symbolic name with local address data
710
Router sends packet to local device having the located symbolic name
715

Figure 7

METHOD ENABLING NETWORK ADDRESS TRANSLATION OF INCOMING SESSION INITIATION PROTOCOL CONNECTIONS BASE ON DYNAMIC HOST CONFIGURATION PROTOCOL ADDRESS ASSIGNMENTS

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] This invention relates to the field of network address assigning, and, more specifically, to a system, method, and apparatus for enabling Network Address Translation (NAT) of incoming Session Initiation Protocol (SIP) connections based on Dynamic Host Configuration Protocol (DHCP) address assignments.

[0003] 2. Background of the Invention

[0004] Local area networks (LANs) have been used with network devices such as personal computers. A LAN typically has a set number of unique Internet Protocol (IP) addresses for all of the devices on the LAN. More specifically, multiple computers on the LAN may be represented by the same IP address and use the same router(s). In such embodiments, there may be 10 computers, for example, assigned to one router, where the router has its own unique IP address.

[0005] In such a LAN, Network Address Translation (NAT) allows a single device, such as a router, to act as an agent between the Internet, or "public network", and a local, or "private", network. This means that only a single, unique IP address is required to represent an entire group of computers.

[0006] In such an embodiment, a major problem with using NAT is to locate the correct device on the internal network when a packet from the Internet arrives at the router, because all packets received from the Internet are addressed to the router and not to the devices behind the router. Configuring static mappings in the router can, in some cases, solve the problem. For example, the router may be configured to send all World Wide Web (WEB) traffic to a specific PC behind a router, and send all File Transfer Protocol (FTP) traffic to a different specified PC behind the router. However, the problem with this type of static mapping is that it requires specific configuration of the router, which may be expensive for an ISP shipping thousands of routers. Moreover, it is problematic if several PCs are performing the same service (FTP, WEB, etc.).

[0007] When a connection is initiated from a device on the internal network to an external device, the access device can always establish the NAT mapping without the use of any additional information. However, when using NAT, connections may only be made from inside a local network to a location outside of the network. A device outside the network cannot connect to a device on the local network without the router being specifically configured to do so. Therefore, the prior art suffers from a serious inefficiency in that a connection cannot be initiated with a device on a LAN by a device outside the LAN without specific configuration of the router at the LAN.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] **FIG. 1** illustrates a general overview of a system according to an embodiment of the invention;

[0009] **FIG. 2** illustrates a basic DHCP packet according to an embodiment of the invention;

[0010] **FIG. 3** illustrates an additional option field portion of a DHCP packet according to an embodiment of the invention;

[0011] **FIG. 4** illustrates a process by which a device is assigned a local IP address according to an embodiment of the invention;

[0012] **FIG. 5** illustrates an association table according to an embodiment of the present invention;

[0013] **FIG. 6** illustrates a process by which a packet is sent from a local device to a destination address on the Internet according to an embodiment of the present invention; and

[0014] **FIG. 7** illustrates a process by which packets are received and routed to the destination device on a local network.

DETAILED DESCRIPTION

[0015] An embodiment of the present invention includes a device that simultaneously acts as a Dynamic Host Configuration Protocol (DHCP) server and a Network Translation Address, (NAT) apparatus. The device may be used within an access router connected to the Internet. Such a device routes incoming packets to devices on a network based upon symbolic names acquired by a DHCP program running on the DHCP server. The device allows an incoming Session Initiation Protocol (SIP) Internet Protocol (IP) call originating from the Internet to be routed to the correct device on the Local Area Network (LAN) segment that uses a private IP address.

[0016] DHCP is a software program that automatically assigns IP addresses to client stations logging onto an IP network. It eliminates the need to manually assign permanent IP addresses. DHCP software typically runs on servers and is also found in network devices such as Integrated Services Digital Network (ISDN) routers and modem routers that allow multiple users access to the Internet. NAT is an Internet Engineering Task Force (IETF) standard that allows an organization to present itself to the Internet with one address. NAT converts the address of each LAN node into one IP address for the Internet and vice versa. It also serves as a firewall by keeping individual IP addresses hidden from the outside world. SIP is a protocol that provides IP telephony services, such as realtime, interactive voice and videoconferencing over LANs and the Internet. It allows any combination of voice, video and data to be transported.

[0017] **FIG. 1** illustrates a general overview of the system according to an embodiment of the invention. In an embodiment of the invention, a number of devices are coupled to an access router **115** capable of transmitting and receiving data via the Internet. **FIG. 1** illustrates an embodiment where a first computer **100**, a second computer **105**, and a SIP IP telephone **110** all reside on a LAN connected to the router **115**. The first computer **100** has a host name, or symbolic name, "Victor." The second computer **105** has a symbolic name "Hugo." The SIP IP telephone **110** has the symbolic name "Yrsa."

[0018] The first computer **100**, the second computer **105**, and the SIP IP telephone **110** are all connected to the access router **115**, which serves as the pathway for communication between them and destinations on the Internet **120**. For the first computer **100** to send data to a destination address on the Internet, the first computer **100** must send a packet to the router **115**, which then sends the packet to the destination address on the Internet **120**.

[0019] In order for a device on the LAN to receive packets of data from a site on the Internet, the router **115** must be configured to route certain packets to a particular device. In other words, the router **115** must extrapolate, from a received packet, the destination address of the packet. To determine which packets must be routed to which devices on the LAN, the router **115** typically has to have prior knowledge about each of the devices.

[0020] To receive and transmit packets over the LAN, or to an Internet site outside of the LAN, a device must have an IP address. As shown in **FIG. 1**, the first computer **100** has the "private" IP address 10.0.1.1., the second computer **105** has the private IP address 10.0.1.2, and the SIP IP telephone **110** has the private IP address 10.0.1.3. A private IP address is an IP address that is not known or directly accessible by a device outside the LAN. In this example, the access router **115** has the "public" IP address 89.20.171.92. A public IP address is accessible by a device inside or outside the LAN. Whenever a packet is sent to the LAN from a destination on the Internet **120**, the packet is sent to the router's **115** public IP address. Once received, the router **115** may then transmit the packet to the local IP address of one of the devices on the LAN.

[0021] In an embodiment of the invention, a variable number of devices may be hooked up to a router **115** over the LAN. For a device to transmit and receive data from outside the network, the device may be assigned a local IP address. A router **115** may be utilized to assign IP addresses to devices on the LAN. To assign a device a local IP address, the device may send an IP address request to the router **115**, which then assigns a local IP address to the device. Each time a device is powered down, and then powered back up, it may be assigned an IP address that need not necessarily be identical to the IP address assigned to the device before being powered down. DHCP is a program, executable by a router **115**, that may be used to assign a local IP address to a device on the LAN.

[0022] **FIG. 2** illustrates a basic DHCP packet **200** according to an embodiment of the invention. When a device on the network sends an IP address assignment request to the router **115**, the request is in the form of a DHCP packet **200**. The packet contains various fields of information, such as operation (op) code **205**. Op code **205** is used to signify whether the packet is a request for an IP address or an assignment of an IP address. If an IP address request is sent, the op code **205** for the DHCP packet is set to "1". A DHCP server, which may be located at the router **115**, responds to the request by sending a DHCP packet with op code **205** set to "2".

[0023] In the DHCP response, the IP address assigned to client is stored in the "yiaddr" field **2210**. Although a basic DHCP packet **200** does not contain the client name, most clients include an optional field in the "options" field **220** of the DHCP request packet **200**.

[0024] **FIG. 3** illustrates an additional host option field **300** portion of a DHCP packet according to an embodiment of the invention. The host option field **300** is utilized to store the symbolic name of a device requesting an IP address. The host option field **300** is located in the options field **220** of the DHCP request packet **200**. The host option field **300** is comprised of a plurality of bytes. The first byte **305** represents the DHCP option code for the option field. A DHCP option code of "12" represents the host name option. The second byte **310** represents the length of the host name. **FIG. 3** shows the bytes in which a host name having four characters may be stored. The first byte **315**, the second byte **320**, the third byte **325**, and the fourth byte **330** may be stored in consecutive bytes in the host option field **300**. In the event that the symbolic name "Victor" were to be stored in the host option field **300**, the second byte would be set to "6", the length of the host name. There would then be "6" bytes in which one of the letters of the name would be stored, respectively.

[0025] In an embodiment of the invention, the router **115** does not have any information concerning the name of any devices on the LAN before those devices send an IP address request. When the router **115** receives an IP address request in the form of a DHCP packet, the router **115** takes the symbolic name of the device from the host option field **300**, assigns the IP address, and maintains a table in which the assigned IP address is associated with the symbolic name of the device. For example, if the DHCP server assigns the local IP address 10.0.01.1 to the device having the symbolic name "Victor", the table will associate the name "Victor" with the local IP address 10.0.1.1.

[0026] **FIG. 4** illustrates a process by which a device is assigned a local IP address according to an embodiment of the invention. First, the device is booted **400**. Next, the device sends **405** an IP request to the DHCP server. The DHCP server is typically located at the router **115**. The device need not have knowledge of the location of the DHCP server when booted. In an embodiment of the present invention, a device may be booted, and then may send a DHCP packet **200** requesting an assignment of an IP address to all devices on the LAN. The device having the DHCP server will receive a DHCP packet **200**, assign an IP address to the device, and send a DHCP response packet to the device. The DHCP response packet contains the local IP address assigned to the device.

[0027] Next, at step **410**, the DHCP server receives the IP request. The DHCP server then assigns **415** a local IP address to the device, and stores the symbolic name of the device in memory. The symbolic name of the device is associated **420** with the assigned IP address and is then stored in memory. Finally, a DHCP response packet having the assigned IP address is sent **425** to device.

[0028] An embodiment of the present invention uses a table of symbolic names and assigned local IP addresses to route incoming packets to devices on the LAN. Referring to **FIG. 1**, the first computer **100** has a symbolic name Victor. When the first computer **100** initially boots, it sends a DHCP IP address request packet to the DHCP server at the router **115**. The router **115** then assigns the first computer **100** a local IP address. In this case, the local IP address is "10.0.1.1". If a packet is received, from outside the LAN, by the router **115** and is addressed to "Victor" at the public IP

address "89.20.171.92", the router **115** uses the association table to determine which device on the LAN has the symbolic name "Victor." In such an instance, the packet would be received by the router **115** and sent to the first computer **100**.

[**0029**] **FIG. 5** illustrates an association table **500** according to an embodiment of the present invention. After all of the devices on the LAN illustrated in **FIG. 1** have been assigned local IP addresses, the association table **500** for the LAN is complete. The association table **500** has a "Host Name" column **505** and an "Assigned IP address" column **510**. For the LAN illustrated in **FIG. 1**, the host names are "Victor", "Hugo", and "Yrsa", and the assigned IP addresses are "10.0.1.1", "10.0.1.2", and "10.0.1.3", respectively.

[**0030**] When a packet is sent from a device on the LAN to the router **115**, and then to a destination on the Internet, the device sends a packet with the device's local IP address and port number. The IP address is utilized to identify the device, and the port number indicates the service on the device. For example, if the IP address "100.100.100.100" is an HTTP server, its port number is "80", the industry standard port number for HTTP. If it is a Telnet server, its port number is "23", the industry standard port number for Telnet.

[**0031**] An embodiment of the present invention may use NAT to present the entire LAN, and all devices located thereon, as having only the public IP address of the router **115**. In the example illustrated in **FIG. 1**, the public IP address of the LAN is "89.20.171.92", the IP address of the router **115**. All packets received by the network, but meant for any of the devices on the LAN, are addressed to the public IP address of the router **115**. Therefore, the router **115** is configured to route packets to particular devices on the LAN. If the second computer **105**, with the symbolic name "Hugo", initiates a connection to an IP address on the Internet, such as "95.10.1.5", the router **115** creates a NAT session entry for second computer **105**. The entry contains an instruction that traffic from 95.10.1.5 sent to public IP address 89.20.171.92 should be forwarded to 10.0.1.2. Also, packets sent from 10.0.1.2 are altered to contain the public IP address 89.20.171.92 as the source IP address. So when a packet from the address 95.10.1.5 arrives from the Internet, the router **115** uses the stored NAT entry and forwards the packet to 10.0.1.2.

[**0032**] When a packet is sent from a device on the network to a device on the Internet outside the network, the packet contains a source IP address and port number, and a destination IP address and port number. If the first computer **100**, "Victor", sends a packet destined for a HTTP server at the IP address "100.100.100.100", the packet would contain the source IP address "10.0.1.1" and a source port number. The source port number is chosen by the first computer **100**. For example, the first computer may assign the port number "1050" as the source port. The destination IP address is "100.100.100.100" and the destination port number is "80". When the router **115** receives the packet, it first verifies that no other devices on the LAN are already using the source port "1050". If any other devices are using that port number, the router assigns a new source port number to the packet. Also, the router **115** changes the source IP address from 10.0.0.1 to the public IP address of the router, "89.20.171.92".

[**0033**] **FIG. 6** illustrates a process by which a packet is sent from a local device to a destination address on the Internet according to an embodiment of the present invention. First, the local device sends **600** a packet to the router **115**. The packet contains a source local IP address and port number, and a destination IP address and port number. Next, the router **115** translates **605** the local IP address to the public IP address. More specifically, the router **115** removes the local IP address from the packet and inserts the public IP address. In the embodiment illustrated in **FIG. 1**, the public IP address "89.20.171.92" would be inserted into the packet. The router **115** then changes **610** the source port number in the packet if another local device is already using the same source port number. Finally, the router **115** sends **615** the packet to the destination IP address over the Internet.

[**0034**] When a connection is not initiated by a device on the LAN, the router **115** is configured to send a received packet to the correct device on the LAN. In an embodiment of the present invention, the system uses the association table **500** to determine which local device to route an incoming packet. For example, an incoming packet may have the symbolic name of the destination device stored in the packet payload of the incoming packet. The system can then extract the symbolic name from the packet, determine the local IP address from the association table **500**, and route the packet to the correct local device. For example, in the embodiment shown in **FIG. 1**, a packet sent the public IP address "89.20.171.92" addressed to the symbolic name "yrsa@89.20.171.92" would be routed to the local IP address "10.0.1.3", which corresponds to the symbolic name "Yrsa". An SIP IP telephone connection can therefore be initiated by a device outside the LAN by addressing a packet to the public IP address of the router **115**, and including the symbolic name "yrsa@89.20.171.92" in the packet payload.

[**0035**] **FIG. 7** illustrates a process by which packets are received and routed to the destination device on a local network. First, the router **155** receives **700** a packet from a remote location on the Internet. Next, the router **115** searches **705** in the packet payload for a symbolic name address. The router **115** utilizes the association table **500** to match **710** the symbolic name with an associated local IP address, if there is one. Finally, the router **115** sends **715** the packet to the local device having the located symbolic name.

[**0036**] While the description above refers to particular embodiments of the present invention, it will be understood that many modifications may be made without departing from the spirit thereof. The accompanying claims are intended to cover such modifications as would fall within the true scope and spirit of the present invention. The presently disclosed embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims, rather than the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

1-26. (canceled)

27. A method, comprising:

receiving, at a first network device, respective Dynamic Host Configuration Protocol (DHCP) requests issued by respective devices in a set of devices, respective ones of the DHCP requests including a symbolic identifier of the device issuing the DHCP request in an options field of the DHCP request;

responding, by the first network device, to the respective DHCP requests with respective DHCP responses, respective ones of the DHCP responses including an Internet Protocol address assigned by the first network device to the device issuing the DHCP request;

storing, by the first network device, data associating the respective Internet Protocol addresses assigned by the first network device with the, respective, symbolic identifiers;

receiving, at the first network device, a Session Initiation Protocol (SIP) packet to initiate an SIP Internet Protocol telephone connection from a device other than a device that issues a DHCP request to the first network device, the SIP packet including one of the symbolic identifiers and the Internet Protocol address of the first network device;

performing a lookup of the one of the symbolic identifiers in the received SIP packet in the data associating the respective Internet Protocol addresses assigned by the first network device with the, respective, symbolic identifiers; and

routing an SIP packet to initiate an Internet Protocol telephone connection to the device corresponding to the Internet Protocol address associated with the symbolic identifier included in the received SIP packet.

28. The method of claim 27, wherein the received SIP packet includes the one of the symbolic identifiers and the Internet Protocol of the first network device in a format of:

symbolic-identifier@Internet-Protocol-address-of-the-first-network-device.

29. The method of claim 27, further comprising:

receiving, at the first network device from a one of the set of devices that issued a DHCP request to the first network device, an SIP packet to initiate an SIP Internet Protocol telephone connection that includes the Internet Protocol address of the device that issued a DHCP request to the first network device and a destination Internet Protocol address; and

transmitting an SIP packet toward the destination Internet Protocol address that replaces the Internet Protocol address of the device that issued a DHCP request to the first network device with the Internet Protocol address of the first network device.

30. An apparatus, comprising logic to:

receive, at a apparatus, respective Dynamic Host Configuration Protocol (DHCP) requests issued by respective devices in a set of devices, respective ones of the DHCP requests including a symbolic identifier of the device issuing the DHCP request in an options field of the DHCP request;

respond, by the apparatus, to the respective DHCP requests with respective DHCP responses, respective ones of the DHCP responses including an Internet Protocol address assigned by the apparatus to the device issuing the DHCP request;

store, by the apparatus, data associating the respective Internet Protocol addresses assigned by the apparatus with the, respective, symbolic identifiers;

receive, at the apparatus, a Session Initiation Protocol (SIP) packet to initiate an SIP Internet Protocol telephone connection from a device other than a device that issues a DHCP request to the apparatus, the SIP packet including one of the symbolic identifiers and the Internet Protocol address of the apparatus;

perform a lookup of the one of the symbolic identifiers in the received SIP packet in the data associating the respective Internet Protocol addresses assigned by the apparatus with the, respective, symbolic identifiers; and

route an SIP packet to initiate an Internet Protocol telephone connection to the device corresponding to the Internet Protocol address associated with the symbolic identifier included in the received SIP packet.

31. The apparatus of claim 30, wherein the received SIP packet includes the one of the symbolic identifiers and the Internet Protocol of the apparatus in a format of:

symbolic-identifier@Internet-Protocol-address-of-the-apparatus.

32. The apparatus of claim 30, further comprising logic to:

receive, at the apparatus from a one of the set of devices that issued a DHCP request to the apparatus, an SIP packet to initiate an SIP Internet Protocol telephone connection that includes the Internet Protocol address of the device that issued a DHCP request to the apparatus and a destination Internet Protocol address; and

transmit an SIP packet toward the destination Internet Protocol address that replaces the Internet Protocol address of the device that issued a DHCP request to the apparatus with the Internet Protocol address of the apparatus.

33. A system, comprising:

multiple networked devices including a first network device; and

logic to provide Internet Protocol telephone connections by:

receiving, at a first network device, respective Dynamic Host Configuration Protocol (DHCP) requests issued by respective devices in a set of devices, respective ones of the DHCP requests including a symbolic identifier of the device issuing the DHCP request in an options field of the DHCP request;

responding, by the first network device, to the respective DHCP requests with respective DHCP responses, respective ones of the DHCP responses including an Internet Protocol address assigned by the first network device to the device issuing the DHCP request;

storing, by the first network-device, data associating the respective Internet Protocol addresses assigned by the first network device with the, respective, symbolic identifiers;

receiving, at the first network device, a Session Initiation Protocol (SIP) packet to initiate an SIP Internet Protocol telephone connection from a device other than a device that issues a DHCP request to the first network device, the SIP packet including one of the

symbolic identifiers and the Internet Protocol address of the first network device;

performing a lookup of the one of the symbolic identifiers in the received SIP packet in the data associating the respective Internet Protocol addresses assigned by the first network device with the, respective, symbolic identifiers; and

routing an SIP packet to initiate an Internet Protocol telephone connection to the device corresponding to the Internet Protocol address associated with the symbolic identifier included in the received SIP packet.

34. The system of claim 33, wherein the received SIP packet includes the one of the symbolic identifiers and the Internet Protocol of the first network device in a format of:

symbolic-identifier@Internet-Protocol-address-of-the-first-network-device.

35. The system of claim 33, further comprising:

receiving, at the first network device from a one of the set of devices that issued a DHCP request to the first network device, an SIP packet to initiate an SIP Internet Protocol telephone connection that includes the Internet Protocol address of the device that issued a DHCP request to the first network device and a destination Internet Protocol address; and

transmitting an SIP packet toward the destination Internet Protocol address that replaces the Internet Protocol address of the device that issued a DHCP request to the first network device with the Internet Protocol address of the first network device.

* * * * *