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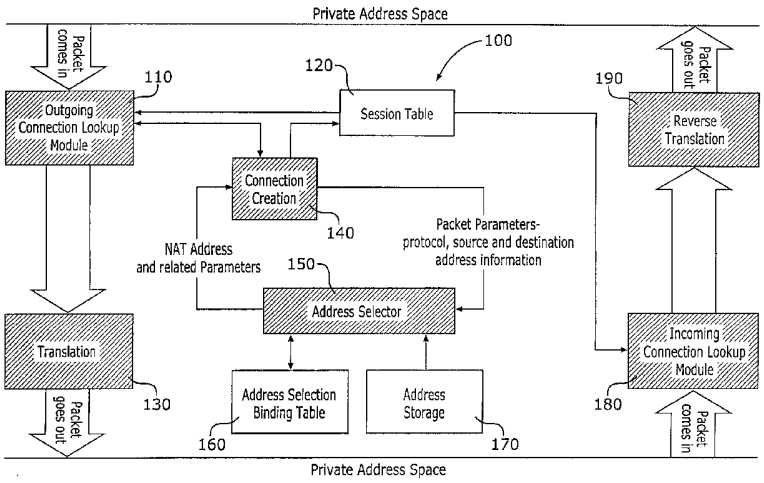
(54) Title: INTELLIGENT NETWORK ADDRESS TRANSLATOR AND METHOD FOR NETWORK ADDRESS TRANSLATION



(57) Abstract: An intelligent network address translation system and methods for intelligent network address translation. The invention analyzes all data packets being communicated between the private address realm and the public address realm and performs a predefined mode of network address translation based on the packet type. By analyzing every packet that the network encounters and adjusting the network address translation mode based on the packet type, the system and method of the present invention is able to adjust the mode of network address translation dynamically during a network user's ongoing network session. Additionally, by basing which mode of translation will be employed based on packet type the translation method of the present invention insures that IP addresses are distributed efficiently and distribution of the amount of addresses is minimized.

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INTELLIGENT NETWORK ADDRESS TRANSLATOR AND METHOD FOR NETWORK ADDRESS TRANSLATION

FIELD OF THE INVENTION

The present invention relates generally to communication networks. More particularly, the present invention provides for a network address translator that analyzes each data packet according to data packet type (i.e., protocol and destination address) to determine a mode of network address translation.

BACKGROUND OF THE INVENTION

Network Address Translation (NAT) is a term used to describe the method by which Internet Protocol addresses (IP addresses) used within one network are mapped (i.e., translated) to a different IP address known within another network, in an attempt to provide transparent routing to host computers. One network is designated the inside network and the other is the outside. Typically, a company maps its local inside network addresses to one or more global outside IP addresses and un-maps the global IP addresses on incoming packets back into local IP addresses. This helps ensure security since each outgoing or incoming request must go through a translation process that also offers the opportunity to qualify or authenticate the request or match it to a previous request. NAT also conserves on the number of global IP addresses that a company needs and it lets the company use a single IP address in its communication with the world.

Network Address Translation allows a single device, such as a gateway device or 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 hosts. The impetus towards increasing use

of NAT comes from a number of factors including, a world shortage of IP addresses, security needs and ease and flexibility of network administration.

Traditionally NAT has two modes of operation – basic NAT and Network Address Port Translation (NAPT).

Basic NAT provides for a group of public host IP addresses to be assigned to a NAT gateway device. In implementation, basic NAT operates by providing for one to one mapping of private addresses to public addresses. This one to one mapping can either be done statically or dynamically. In static NAT, an unregistered IP address is mapped to a registered IP address on a one-to-one basis (i.e., the IP address of the host is always translated to the same address). In dynamic NAT, an unregistered IP address is mapped to a registered IP address from a group of registered IP addresses (i.e., the IP address of the host is translated to the first available address).

In contrast to basic NAT, NAPT maps all addresses in the private realm to a single public domain address. NAPT distinguishes network sessions coming from the same or different private IP addresses by mapping the private source IP address and the private source port to a unique public source port. In this regard, the data packets are translated on the basis of the unique public source port using a single public IP address. NAPT allows for mapping multiple private addresses to one public address by associating each host with a port (i.e., source IP and source port to source port mapping).

These two modes of operation, basic NAT and NAPT, both provide benefits to the network provider and/or network user. Basic NAT allows for one-to-one mapping/translation exists between the private address and the public address. However, basic NAT requires that a sizable pool of addresses be available for one-to-one mapping and, as such, basic NAT inherently has a poor IP address reusability factor. In this regard, basic NAT is only capable of supporting as many Virtual Private Network (VPN) connections as the number of public IP addresses available in the pool at any point in time.

NAPT, which provides mapping all addresses in the private realm to a single public domain address, does not require the same magnitude of available public addresses. However, in the NAPT environment the need for less public

addresses is offset by a system that offers limited functionality for certain protocols and applications, such as VPN.

Recent network advancements have attempted to provide the capability to implement both basic NAT and NAPT in one comprehensive network system. For example, United States Patent No. 6,058,431, entitled "System and Method for Network Address Translation as an External Service in the Access Server of a Service Provider", issued in the name of inventors Srisuresh et al., on May 2, 2000. The Srisuresh '431 patent describes an external network address translation service, which performs NAT and NAPT, concurrently. Essentially, this service is intended to reduce the cost of stub routers by removing the need for network address translation features in stub routers. In the Srisuresh '431 patent the basis of choosing NAT versus NAPT is the service agreed upon with the stub networks. This decision is made at the inception of the network connection and is fixed throughout the network session. Thus, the Srisuresh '431 patent does not teach a NAT versus NAPT decision process that is adaptable throughout the network session to accommodate the type of service desired by the network user.

Additionally, United States patent application publication number US 2002/0010799, entitled "Communication Data Relay System and Method of Controlling Connectability Between Domains" by Kubota et al., published on January 24, 2002 describes a relay system between two private local area networks. The teaching pertains to connectivity between different routing domains that might be implementing different routing protocols and/or routing data. The relay system requires address translation between the two LANs and similar address translation with the Internet. The publication teaches that the relay may perform basic NAT and NAPT, or IP masquerading, depending upon the address translation module, algorithm, and lookup-table configured for each LAN. However, the Kubuto publication does not teach an address translation process that chooses a mode of translation to efficiently or effectively allocate network addresses.

In the same regard, United States patent application publication number 2002/0087721, entitled "Duplicate Private Address Translating System and Duplicate Address Network System", in the name of inventors Sato et al.,

published on July 4, 2002 describes a duplicate network address translating device which provides translation between private addresses on independent private networks and a global address on the Internet. The device allows separate private networks to maintain duplicate IP addresses by using different protocols or by adding additional independent network address information. The disclosure teaches that basic network address translation (basic NAT) would be unable to communicate between private networks using duplicate identical IP addresses on each of the independent networks. However, the duplicate network address translating system described would perform network address translation (NAT) or network address port translation (NAPT) between the private networks and the Internet via a global address. The teaching relies on Virtual Local Area network (VLAN) tags and Multi-Protocol Label Switching (MPLS) in combination with the source IP and source port to construct a translation table.

Thus, a need remains unfulfilled for an intelligent network address translator capable of improved connectivity, security, and flexible private network administration.

SUMMARY OF THE INVENTION

The present invention provides for an intelligent network address translation system and methods for intelligent network address translation. The invention analyzes all data packets being communicated between the private address relam and the public address realm and performs a predefined mode of network address translation based on the packet type. By analyzing every packet that the network encounters and adjusting the network address translation mode based on the packet type, the system and method of the present invention is able to adjust the mode of network address translation dynamically during a network user's ongoing network session. Additionally, by basing which mode of translation will be employed based on packet type the translation method of the present invention insures that IP addresses are distributed efficiently and distribution of the amount of addresses is minimized. The system and methods of the present invention can accomplish this task without limiting the level of security provided by the translation process.

In addition, the intelligent network address translation system of the present invention provides for a heightened IP address reusability factor. This is apparent because the system provides for different hosts connecting to different network destinations to use the same public IP address, concurrently. The system maps assigned public IP addresses to destination addresses and only denies re-using the same public IP address if subsequent network users are connecting to the same destination address. Another advantage of the present invention is that translation address allocation does not depend on the order in which a network host accesses the system and the order of entry does not determine if a network host is capable of creating a Virtual Private Network (VPN) connection. In a basic NAT type system the amount of IP addresses in the public IP pool will dictate how many network users can be assigned a NAT address. For example, if the public IP pool consists of 100 IP addresses, the first 100 network users that access the system and warrant a network address translation will be assigned the addressed. As such, the 101st user will be denied network address translation. In the present invention, two factors prevent the system denying network address translation based on the order in which a network user accesses the syste. First, network users that access the system may not require a unique address from the public IP pool (i.e., they may only require assignment of the default IP address). Second, in those instances in which a unique IP address is required, IP addresses can be re-used as long as the network user is attempting to access a different destination address than a previously connected network user.

In one embodiment of the invention, a method for network address translation in a communication network includes the steps of determining a data packet type for a data packet being communicated from private hosts to public network services, determining if the data packet type requires assigning an IP address from available public IP addresses and assigning the data packet an IP address from the available public IP addresses if a determination is made that the packet type requires such. Lastly the method includes, translating the address of the data packet to the assigned IP address.

The method described above may further include the step of assigning the data packet a default public IP address and a source port if a determination is made

that the data packet type does not require assigning an IP address from available public IP addresses. The method may also include the steps of storing the assigned IP address in an address binding (i.e., correlation) table that maps the assigned IP address to a data packet destination address and/or the step of storing the assigned IP address in a correlation table that maps the assigned IP address to the private IP address. The storage steps allow for outgoing data packets to be checked for previous network address translation processing, thus hastening data transmission and provides for an effective IP address reusability factor.

In an alternate embodiment of the invention, a method for network address translation in a communications network is defined as, the method including the steps of analyzing each outgoing data packets to determine data packet type, determining, from multiple modes of network address translation, a mode of network address translation for each outgoing data packets based upon the determined data packet type of each outgoing data packet and performing network address translation on outgoing data packets based on the determined mode of network translation. The method allows for the modes of network address translation to include the basic NAT-type translation method of assigning a public IP address from a public IP address pool or the NAPT-type translation the method of assigning a default public IP address and a related source port.

The invention is also defined by a network address translator system for providing network address translation in a communications network. The system includes an address selector module that analyzes the data packet type of outgoing data packets to determine a mode of network address translation and selects a translation address based on the determined mode of network address translation and a translation module in communication with the outgoing connection lookup module that performs network address translation on outgoing data packets using the selected translation address.

Additionally, the network address translator system may include an outgoing connection lookup module that communicates with a connection lookup table to determine if outgoing data packets have previously undergone network address translation and/or a connection creation routine that compiles translation information, including the assigned network address translation for outgoing data

packets, and stores the compiled translation information in the connection lookup table. In order to reverse translate the incoming data packets, the system may include a connection lookup table to determine connection parameters for incoming data packets and a reverse translator module that performs reverse network address translation on incoming data packets based on the determined connection parameters in the connection lookup table.

BRIEF DESCRIPTION OF THE DRAWINGS

Having thus described the invention in general terms, reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

Figure 1 is a block diagram of a communication network implementing intelligent network address translation, in accordance with an embodiment of the present invention.

Figure 2 is a block diagram of the system for intelligent network address translation, in accordance with an embodiment of the present invention.

Figure 3 is a flow diagram of a method for intelligent network address translation, in accordance with an embodiment of the present invention.

Figure 4 is a flow diagram of the sub-method for address selection within the method for intelligent network translation, in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout.

The present invention is described as an intelligent network address translator that is implemented in a communication network. The intelligent network address translator analyzes each outgoing data packet based on packet

type (i.e., protocol and destination address) and decides, based on the packet type, what mode of network address translation will be applied. In one embodiment the modes of network address translation will include mapping addresses in the private realm to a single public domain Internet Protocol (IP) address and source port or assigning a public IP address from a pool of available IP addresses. In effect, the intelligent network address translator of the present invention is able to dynamically change network address translation modes during an on-going network session by recognizing changes in packet types.

For example, a network user initiates a network session from a host, begins accessing a public network, and the intelligent network translator of the present invention recognizes the packet type. Upon recognition of the packet type the translator assigns a mode of network address translation based upon the functional requirements of the protocol (i.e., the packet type). If the functionality of the protocol is not dependent on assignment of globally unique IP addresses per destination server, then the data packets will typically be mapped to a default public domain IP address and source port. If, however, later in the same network session, the network user begins accessing a private network by using a Virtual Private Network (VPN), the intelligent network address translator recognizes a change in data packet type. In this instance, if the packet type and the protocol require globally unique IP addresses to function, the data packets may be assigned a public IP address from the available pool of IP addresses. As such, the intelligent network translator of the present invention is able to more effectively assign IP addresses and limit the amount of IP addresses that are being used at any given time.

In accordance with an embodiment of the present invention, the components, process steps, and/or data structures of the intelligent network address translator are implemented using a gateway device. Different implementations may be used and may include other types of operating systems, computing platforms, computer programs, and/or general-purpose machines. In addition, those of ordinary skill in the art will readily recognize that devices of a less general purpose nature, such as hardwired devices, devices relying on FPGA (Field Programmable Gate Array) or ASIC (Application Specific Integrated

Circuit) technology, or the like, may also be used without departing from the scope and spirit of the inventive concepts disclosed herewith.

Figure 1 depicts a block diagram of a communication network **10** that implements an intelligent network translation system, in accordance with an embodiment of the present invention. The communication network typically includes a plurality of user/subscriber hosts **12** that access the communication network in order to gain access to other networks or Internet services. The communication network also includes a gateway device **14** that provides an interface between the plurality of hosts and the various networks or other online services. Most commonly, the gateway device is located proximate to the hosts at a relatively low position in the structure of the overall network. However, the gateway device can be located at a higher position in the overall network structure such as at a Point of Presence (PoP) of Network Operating Center (NOC), if so desired. Although the gateway device can be physically embodied in many different fashions, the gateway device typically includes a controller and a memory device in which software is stored that defines the operational characteristics of the gateway device. Alternatively, the gateway device can be embedded within another network device, such as the access controller or a router, or the software that defines the functioning of the gateway device can be stored on a PCMCIA card that can be inserted into the host in order to automatically reconfigure the host to communicate with a different communications network.

The communication system **10** also typically includes an access controller **16** positioned between the hosts **12** and the gateway device **14** for multiplexing the signals received from the plurality of hosts onto a to gateway device link. Depending upon the medium by which the hosts are connected to the access controller, the access controller can be configured in different manners. For example, the access controller can be a digital subscriber line access module (DSLAM) for signals transmitted via regular telephone lines, a cable modem termination system (CMTS) for signals transmitted via coaxial/optical fiber cables, a wireless access point (WAP) for signals transmitted via a wireless network, a switch or the like. As also shown in Figure 1, the network system typically includes one or more routers **18** and/or servers

(not shown in Figure 1) in communication with a plurality of networks **20** or other Internet services **22**. While the communication network is depicted to have a single router, the communication network will typically have a plurality of routers, switches, bridges, or the like that are arranged in some hierarchical fashion in order to appropriately route traffic to and from the various networks or other Internet services. In this regard, the gateway device typically establishes a link with one or more routers. The routers, in turn, establish links with the servers of other networks or other online service providers, such as Internet service providers, based upon the subscriber's selection.

In accordance with an embodiment of the present invention, the components, process steps, and/or data structures of the intelligent network address translator **24** are implemented using gateway device **14**. Those skilled in the art will realize that the intelligent network address translator may be implemented in other network devices, such as traditional routers, servers or the like. In addition, the gateway device may communicate with external storage devices (not shown in Figure 1) in order to implement the system for intelligent network address translation of the present invention.

Figure 2 is a block diagram of the intelligent network address translation system **100**, in accordance with an embodiment of the present invention. Outgoing data packets that are being transmitted from the private address space, typically a network host, to the public address space, typically a network service or the Internet, are communicated to the outgoing connection lookup module **110**. The outgoing connection lookup module is in communication with the session table **120**. The session table provides a log of all current network sessions/connections, the corresponding translated network address that has been assigned the current network sessions/connection and other session/connection related data, such as source and destination addresses, session state, time outs and sequence number handling. In this regard, the outgoing connection lookup performs a routine, in conjunction with the session table, to determine if an outgoing data packet has a corresponding network address translation entry in the session table. If a corresponding entry exists in the session table, (i.e., data packets determined to be similar have already undergone intelligent network

address translation) then the data packet and the network address translation information are forwarded to the translation module **130**. The translation routine performs the requisite network address translation by altering address information in the header of the data packet.

The outgoing connection lookup module **110** is in communication with a connection creation routine **140**. If the outgoing connection lookup module determines that no corresponding entry exists for the data packet in the session table **120** then the intelligent network address translator proceeds to the connection creation routine. The connection creation routine serves to compile the requisite connection information, including the translated network address that will subsequently be stored in the session table. The connection creation routine is in communication with the address selector module **150**. The connection creation routine communicates packet parameters, such as, protocol, source address and destination address to the address selector module. The address selector module is responsible for determining the mode of network address translation that is to be implemented based on the packet type of the data packet.

The address selector module **150** is in communication with an address-selection binding table **160** and an address storage unit **170**. The address selection binding maps the network address translation to the destination address and the address storage unit is the resource for all available network address translation addresses.

The address selector module **150** will analyze the data packet to determine the packet type. Packet type will be indicated by the protocols assigned to the data packet. Based on the packet type the data packet will be assigned a mode of network address translation. In one embodiment of the invention, predetermined packet types are specified as requiring assignment of a default public IP address and port (i.e., effectively performing NAPT-type network address translation) and other predetermined packet types are specified as requiring assignment of a public IP address from the pool of available IP addresses.

If the address selector module **150** determines that the packet type

requires assigning a public IP address from the pool of available addresses then the address selector module will determine the data packet's destination address. The address selector module communicates with the address storage **170** to retrieve a public IP address. The destination address is then used to determine if the address-selection binding table **160** has an entry that corresponds to the destination address and the retrieved public IP address. If an entry does exist for the destination address, it means that the corresponding public IP address is being used for another session to the same destination by another network user and therefore this public IP address cannot be used for the current new data packet. In this instance, the address selector module will access the address storage for another public IP address. If no entry exists in the binding table for the destination address then the address selector module assigns the new public IP address to this destination address. Upon assignment of the new IP address, an entry is placed in the binding table to signify that the IP address corresponds to the destination address of the data packet.

The assigned public pool IP translation address and related parameters are communicated by the address selector **150** to the connection creation routine **140** at which a session/connection table entry is compiled and forwarded to the session table **120**. Additionally, the translation network address and related parameters are communicated to the translation module **130** where the translation routine performs the requisite network address translation by altering address information in the header of the data packet.

If the address selector module **150** determines that the packet type requires assigning a default public IP address and a source port then the address selector module will assign the default public IP address and bind the data packet to a corresponding source port of the device that implements the intelligent network address translation.

The default public IP translation address, assigned port and related parameters are communicated by the address selector **150** to the connection creation routine **140** at which a session/connection table entry is compiled and forwarded to the session table **120**. Additionally, the translation network address and related parameters are communicated to the translation module **130** where

the translation routine performs the requisite network address translation by altering address information in the header of the data packet.

Incoming data packets that are being transmitted from the address space, typically a network service or the Internet to the private address space, typically a network host are communicated to the incoming connection lookup module **180**. The incoming connection lookup module is in communication with the session table **120**. The session table provides a log of all current network sessions/connections and, therefore, the session table provides the correlation between the translated network address of the incoming data packet and the private address. The incoming connection lookup module is in communication with the reverse translation module **190**. The incoming connection module communicates the private address and related address information to the reverse translator module and the reverse translator module reconfigures the network address in the header of the data packet such that packets that are forwarded to the private address space indicate the originally assigned private address.

It should be obvious to those of ordinary skill in the art that the modules depicted in Figure 2 can be formed in numerous different ways, but are typically embodied by the controller operating under software control to perform the recited functions.

Figure 3 is a flow diagram of a process for intelligent network address translation, in accordance with an embodiment of the present invention. At step **200**, a data packet arrives at the intelligent network translation system and, at step **210**, the system determines whether the data packet is an outgoing data packet. Outgoing data packets are data packets that emanate from a private address space, such as a network host and are to communicated to the public address space, such as a network service, the Internet or the like. Incoming data packets are data packets that emanate from the public address space and are to be communicated to the public address space. This determination is necessary because outgoing data packets will require network address translation and incoming data packets will require reverse network address translation.

If a determination is made that the data packet is an outgoing data packet then, at step **220**, the system performs a lookup to determine if a connection

exists in corresponding connection memory (i.e., session table). The existence of a connection means that data packets from the same private address have previously been mapped to a translated network address during the current connection and, therefore, no further analysis of the data packet is necessary prior to translation. As such, at step **230**, the determination is made to assess whether a connection is found in the connection memory. If a connection is found in the connection memory then, at step **240**, the process performs the translation using the connection parameters and translation network address found in the connection memory and the outgoing data packets are communicated to the public address realm.

If a connection is not found in the corresponding connection memory, then at step **250**, the process determines that a new connection entry must be determined. Figure 3 illustrates a simplified method for creating a new connection (i.e., selecting a translation network address), in accordance with an embodiment of the present invention. For a more detailed method flow for selecting an address see Figure 4 and the discussion that ensues, infra. At step **260**, the process determines whether the packet type of the data packet has been predetermined to be "special". In this instance, "special" is defined as those packet types that will require a specified mode of network translation. The network administrator is capable of predefining, and changing based on need, which data packet types will be defined as "special". Typically, packet types, which are defined by the packet protocol, will be deemed "special" if they belong to a protocol that does not function if the packets undergo port translation. In one embodiment of the invention, packet types that are determined to be "special" will be assigned, at step **270**, a public IP address from the pool of available IP addresses. If the packet type is not determined to be "special", then, at step **280**, a default public IP address is assigned and a source port is assigned. Once a translation address has been assigned, either from the public IP pool or the default public IP address the process performs the translation, at step **240**, using the assigned translation network address and associated connection parameters and the outgoing data packets are communicated to the public address realm.

If, at step **210**, the data packet is determined to not be an outgoing data it is then deemed to be an incoming data packet that emanated from the public address realm. As such, at step **290**, an incoming lookup connection process is employed to determine the connection corresponding to the translated network address in the data packet. At step **300** the process determines whether an entry exists in the corresponding connection memory. If no entry is found, meaning the connection entry was never established or entered for the outgoing data packets then, at step **310**, the data packet is dropped and no further communication of the data packet ensues. If an entry is found in the corresponding connection memory, then the connection parameters and the private address mapped to translation network address are used, at step **320**, to reverse translate the data packet back to the original private network address and the reverse translated data packets are then communicated to the private address realm.

Figure 4 provides a detailed method for address selection in an intelligent address translation system, in accordance with an embodiment of the present invention. Figure 4 is a more detailed flow of the method illustrated by steps **260-280** of Figure 3. At step **400**, a packet type determination is made by analyzing the data packet and determining the packet's protocol. Once the packet type is determined then the process assesses the packet to determine the mode of network address translation that is required. The system of the present invention will predefine which protocols will dictate which mode of network translation. At step **410**, the process determines if the packet type is deemed special and, thus, requires basic NAT-type network address translation (i.e., assigning a public IP address from the pool of available IP address). If, at step **420**, the determination is made that the packet type is not special and, therefore, does not require basic NAT-type network address translation then the data packet is assigned the default public IP address. In association with assigning the default public IP address, at step **430**, a source port is allocated to the connection.

If the data packet is determined to be "special" and, thus require basic NAT-type processing then, at step **440**, a determination is made as to whether an

IP address is available in the associated public IP pool and an entry corresponding to the IP address and the data packet destination address does not exist in the address binding table. If such an IP address is available, then, at step **450**, the IP address that is available is assigned to the connection as the translation network address. This mapping of the assigned public IP address and the destination address is added to the address binding table. However, if a determination is made that no IP address is available then, at step **460**, no network address translation can be performed on the data packet and the packet is dropped from further communication.

By providing for mapping of public pool IP addresses to destination addresses and only denying reusability of the public pool IP address if it has been mapped to the same destination address that a subsequent network user desires to access, the present invention significantly increases the IP address reusability factor. This allows more potential network users to establish NAT-type connections and significantly lessens the dependency on when a network user accesses the system to determine IP address allocation.

As such, the present invention is capable of intelligent network address translation. The intelligent aspect of the translation system is realized by analyzing different parameters of all data packets being communicated between the private address relam and the public address realm and performing a predefined mode of network address translation based on the packet type. By analyzing every packet that the network encounters and adjusting the network address translation mode based on the packet type, the system and method of the present invention is able to adjust the mode of network address translation dynamically during a network user's ongoing network session. Additionaly, by basing which mode of translation will be employed based on packet type the translation method of the present invention insures that IP addresses are distributed efficiently and distribution of the amount of addresses is minimized.

Many modifications and other embodiments of the invention will come to mind to one skilled in the art to which this invention pertains having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the invention is not to

be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

THAT WHICH IS CLAIMED:

1. A method for network address translation in a communication network, the method comprising:

determining a data packet type for a data packet being communicated from private hosts to public network services, the data packet having a private network address;

determining if the data packet type requires assigning an IP address from available public IP addresses;

assigning the data packet an IP address from the available public IP addresses if a determination is made that the packet type requires such;

translating the private network address of the data packet to the assigned IP address; and

otherwise, assigning the data packet an IP address in accordance with a different mode of network address translation

2. The method of Claim 1, wherein otherwise, assigning the data packet an IP address in accordance with a different mode of network address translation further comprises the step of assigning the data packet a default public IP address and a source port if a determination is made that the data packet type does not require assigning an IP address from available public IP addresses.

3. The method of Claim 1, further comprising the step of determining the availability of IP address from the public IP addresses if a determination is made that the packet type requires assigning an IP address from the available public IP addresses.

4. The method of Claim 1, wherein the step of assigning the data packet an IP address from the available public IP addresses if a determination is made that the packet type requires such further includes the step of determining if a public IP address is currently bound to the destination address of the data packet.

5. The method of Claim 1, further comprising the step of storing the assigned IP address in a correlation table that maps the assigned IP address to a data packet destination address.

6. The method of Claim 1, further comprising the step of storing the assigned IP address in a correlation table that maps the assigned IP address to the private IP address.

7. The method of Claim 1, wherein the step of determining a data packet type for each data packet being communicated from network hosts to network services further comprises determining a protocol for each data packet being communicated from network hosts to network services.

8. A method for network address translation in a communications network, the method comprising the steps of:

analyzing each outgoing data packet to determine data packet type;

determining, from multiple modes of network address translation, a mode of network address translation for each outgoing data packets based upon the determined data packet type of each outgoing data packet; and

performing network address translation on outgoing data packets based on the determined mode of network translation.

9. The method of Claim 8, wherein the step of determining, from multiple modes of network address translation, a mode of network address translation for each outgoing data packet based upon the determined data packet type of each outgoing data packet further comprises determining, from multiple modes of network address translation including a mode defined by assigning a default public IP address and source port, a mode of network address translation for each outgoing data packet based upon the determined data packet type of each outgoing data packet.

10. The method of Claim 8, wherein the step of determining, from

multiple modes of network address translation, a mode of network address translation for each outgoing data packet based upon the determined data packet type of each outgoing data packet further comprises determining, from multiple modes of network address translation including a mode defined by assigning a public IP address from a public IP address pool, a mode of network address translation for each outgoing data packet based upon the determined data packet type of each outgoing data packet.

11. The method of Claim 8, wherein the step of determining, from multiple modes of network address translation, a mode of network address translation for each outgoing data packet based upon the determined data packet type of each outgoing data packet further comprises determining whether to assign a default public IP address and source port or to assign a public IP address from a public IP pool based upon the determined data packet type of each outgoing data.

12. A method for network address translation in a communications network, the method comprising the steps of:

analyzing an outgoing data packet to determine data packet type;

determining if the data packet type requires assigning a public Internet Protocol (IP) address from a public IP address pool;

determining, if the data packet type requires assigning a public IP address from a public IP address pool, the destination address of the data packet;

determining if a first public IP address in the public IP address pool is currently bound to the destination address of the data packet;

assigning the first public IP address to the data packet if the IP addresses is not currently bound to the destination address of the data packet; and

performing network address translation on the outgoing data packet.

13. A network address translator device for providing network address translation in a communications network, the device comprising:

an address selector module that analyzes the data packet type of outgoing data packets to determine a mode of network address translation that is to

be applied to the outgoing data packets and selects a translation address based on the determined mode of network address translation; and

a translation module in communication with the outgoing connection lookup module that performs network address translation on outgoing data packets using the selected translation address.

14. The network address translator of Claim 13, further comprising an outgoing connection lookup module that communicates with a connection lookup table to determine if outgoing data packets have previously undergone network address translation.

15. The network address translator of Claim 14, further comprising a connection creation routine that compiles translation information, including the assigned network address translation for outgoing data packets and stores the compiled translation information in the connection lookup table.

16. The network address translator of Claim 13, further comprising:

an incoming connection lookup module that communicates with a connection lookup table to determine connection parameters for incoming data packets; and

a reverse translator module that performs reverse network address translation on incoming data packets based on the determined connection parameters in the connection lookup table.

17. The network address translator of Claim 13, wherein the mode of network address translation is chosen from the group consisting of (a) assigning a default public IP address and source port and (b) assigning a public IP address from a pool of available IP addresses.

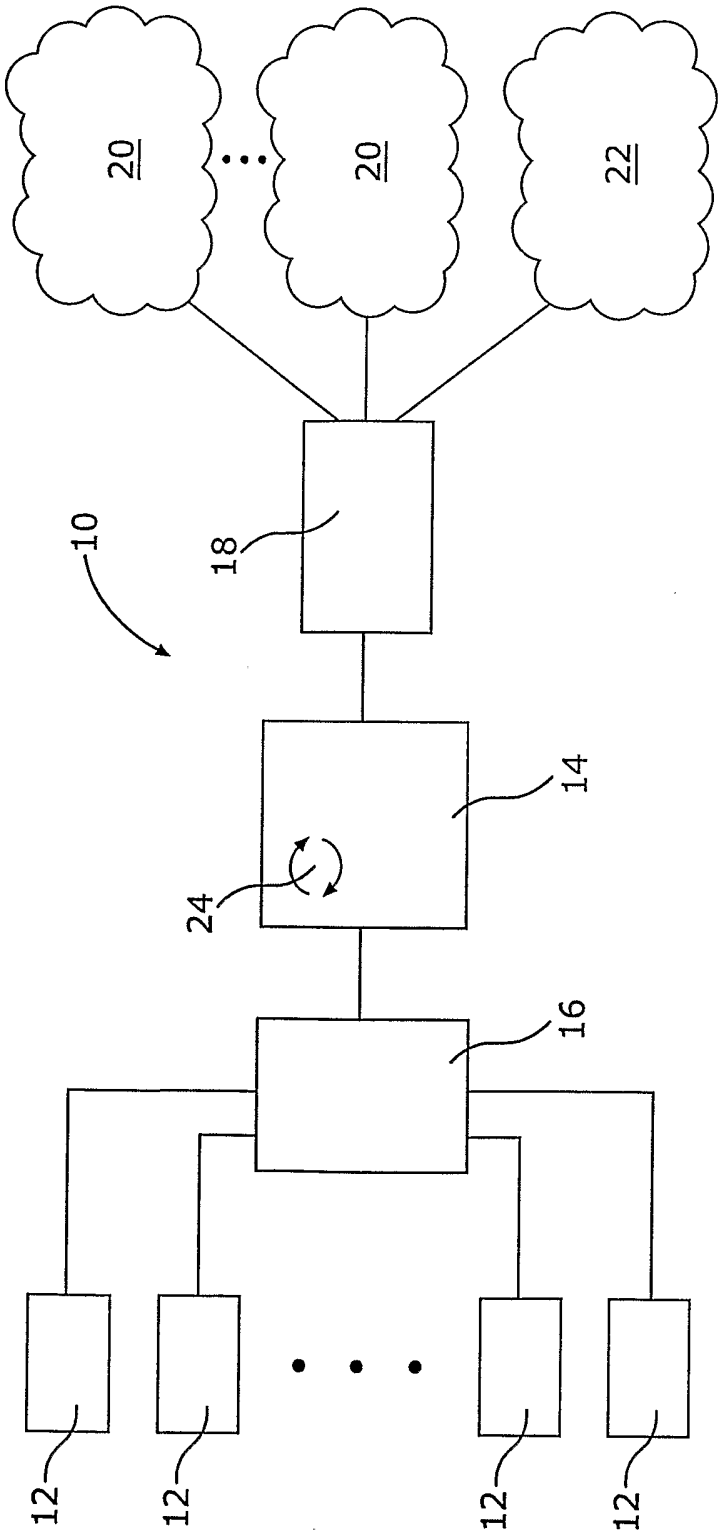

FIG. 1

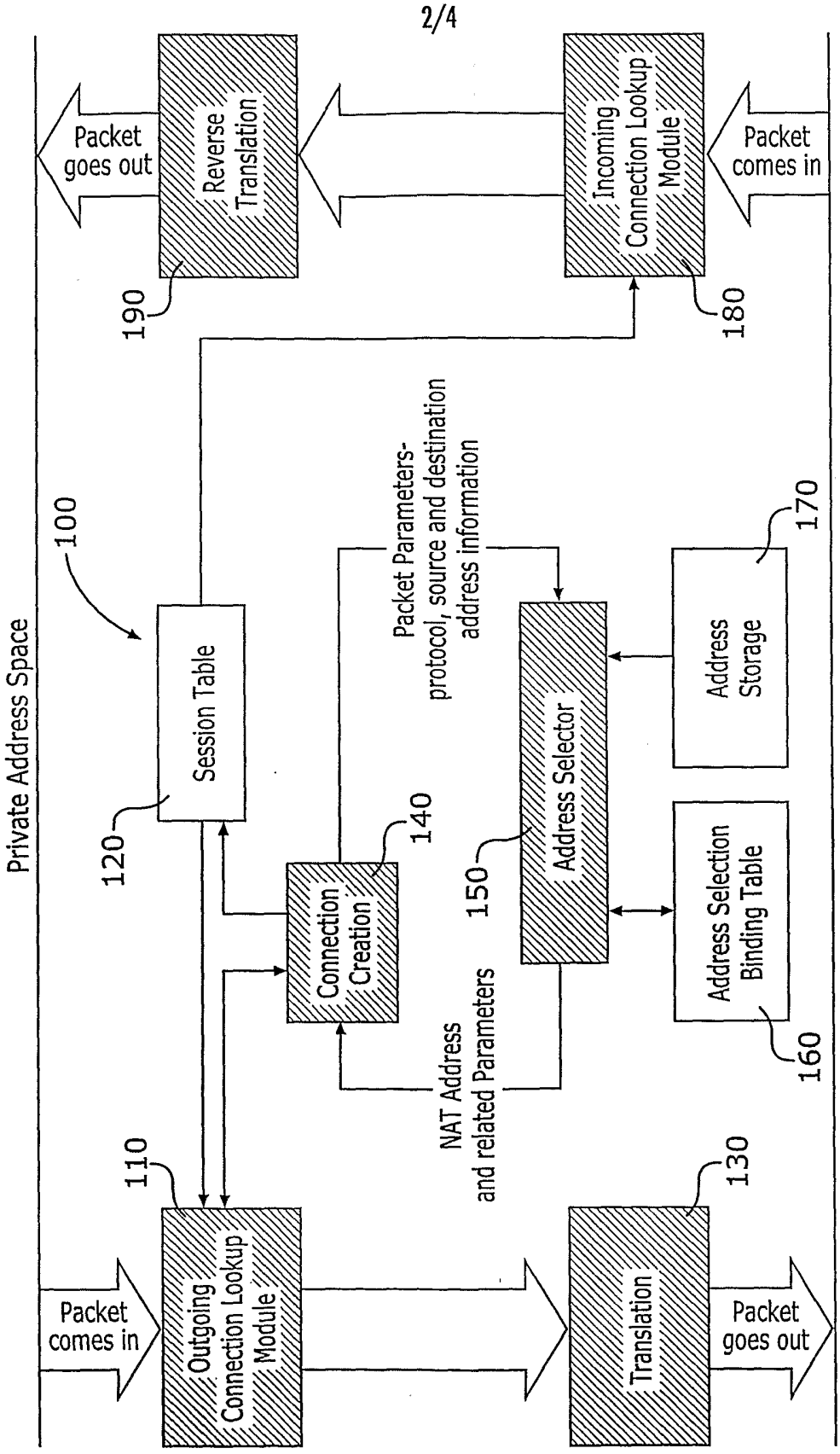
Private Address Space
Packet comes in
Outgoing Connection Lookup Module
110
Translation
130
Packet goes out
Private Address Space
Packet comes in
Incoming Connection Lookup Module
180
Reverse Translation
190
Packet goes out
100
Session Table
120
Connection Creation
140
Address Selector
150
Address Storage
170
Address Selection Binding Table
160
Packet Parameters- protocol, source and destination address information
NAT Address and related Parameters

FIG. 2

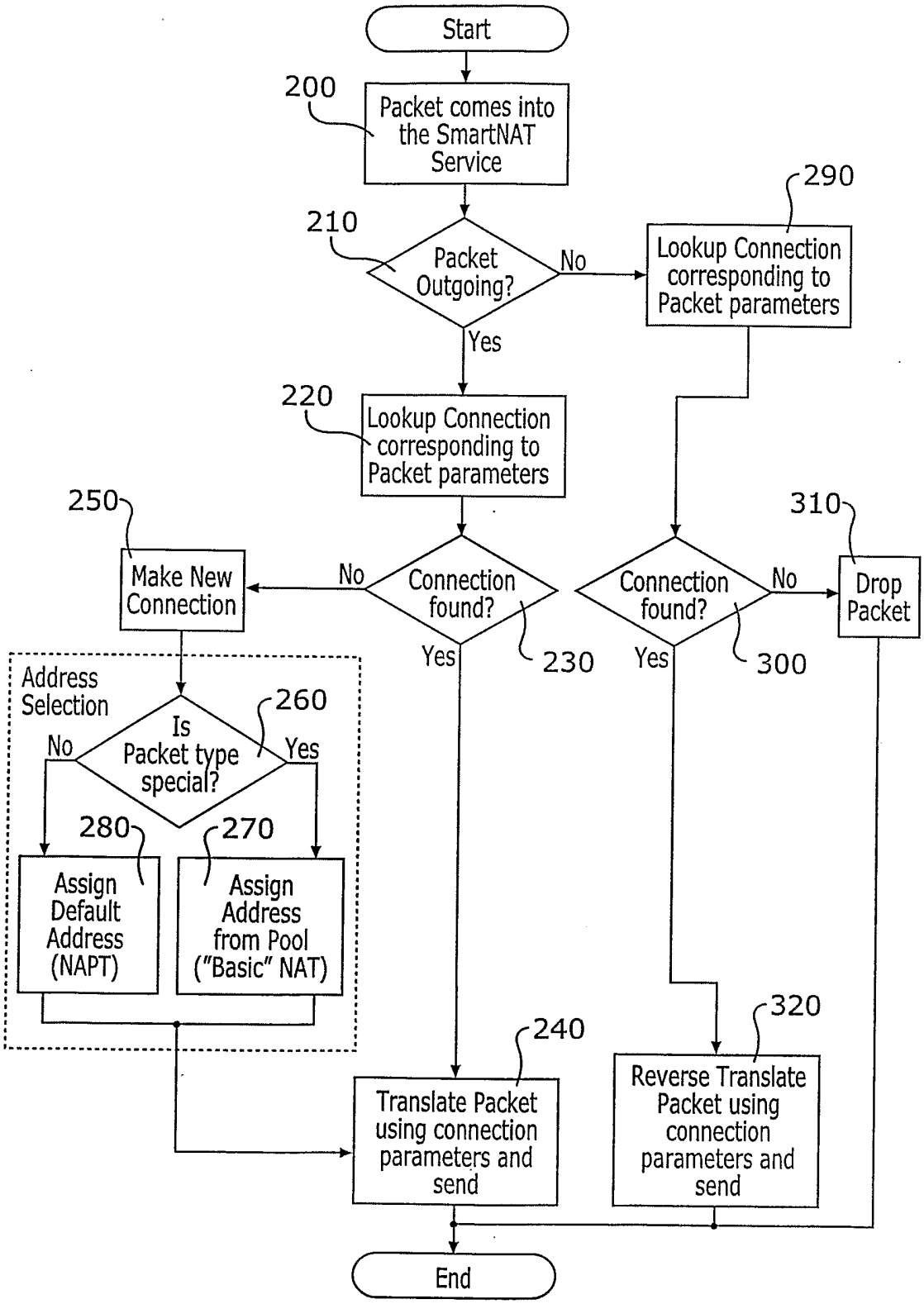
Start
200
Packet comes into the SmartNAT Service
210
Packet Outgoing?
No
Yes
290
Lookup Connection corresponding to Packet parameters
220
Lookup Connection corresponding to Packet parameters
250
Make New Connection
No
Connection found?
230
Yes
Address Selection
260
Is Packet type special?
No
Yes
280
Assign Default Address (NAPT)
270
Assign Address from Pool ("Basic" NAT)
310
Drop Packet
Connection found?
No
300
Yes
240
Translate Packet using connection parameters and send
320
Reverse Translate Packet using connection parameters and send
End

FIG. 3

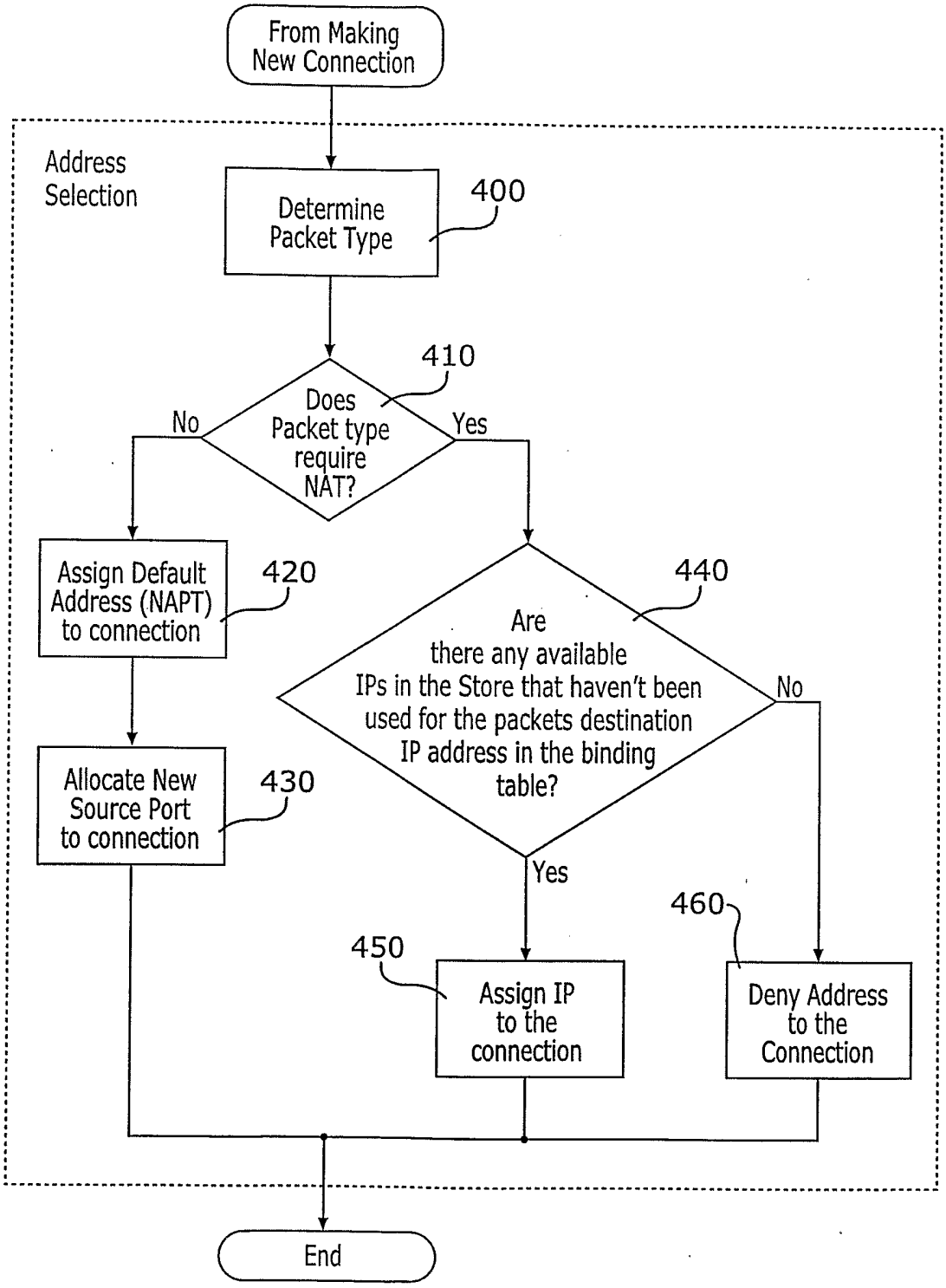
From Making New Connection
Address Selection
Determine Packet Type
400
410
Does Packet type require NAT?
No
Yes
Assign Default Address (NAPT) to connection
420
Allocate New Source Port to connection
430
440
Are there any available IPs in the Store that haven't been used for the packets destination IP address in the binding table?
No
Yes
450
Assign IP to the connection
460
Deny Address to the Connection
End

FIG. 4

INTERNATIONAL SEARCH REPORT

Interna[illegible] Application No
PCT/US 03/04857

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04L29/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, IBM-TDB, INSPEC, COMPENDEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	SRISURESH P ET AL: "RFC 3022 - Traditional IP Network Translator (Traditional NAT)" IETF, January 2001 (2001-01), XP002227044 abstract page 3, line 9 -page 7, line 25 page 8, line 6 -page 9, last line page 12, line 18 -page 12, line 32 figures 1-3	1-4, 8-13,17
Y	--- -/--	5-7, 14-16

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 July 2003	28/07/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Körbler, G

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 03/04857

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
Y	SMITH M.,HUNT R.: "Network Security using NAT and NAPT" ICON 2002. 10TH IEEE INTERNATIONAL CONFERENCE, 30 August 2002 (2002-08-30), pages 355-360, XP002246149 abstract page 355, left-hand column, line 1 -page 355, right-hand column, line 15 page 356, left-hand column, line 21 -page 360, left-hand column, last line figures 1-5 ---	5-7, 14-16
A	WO 99 55056 A (LUCENT TECHNOLOGIES REMOTE ACC) 28 October 1999 (1999-10-28) abstract page 2, line 20 -page 3, line 28 page 4, line 20 -page 6, line 23 page 7, line 18 -page 11, line 10 figures 1-7 ---	1-17
A	WO 02 067531 A (KHAN MD SHAHADATULLAH ;MARWOOD DAVID EVERETT (CA); PICHE CHRISTOPH) 29 August 2002 (2002-08-29) abstract page 2, line 1 -page 3, line 9 page 4, line 4 -page 4, line 12 page 4, line 27 -page 7, line 24 figures 1,2 -----	1-17

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Internat[redacted]l Application No
PCT/US 03/04857

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		AU 3755099 A	08-11-1999
		EP 1074138 A1	07-02-2001
		WO 9955056 A1	28-10-1999
WO 02067531 A	29-08-2002	WO 02067531 A1	29-08-2002