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Autonomous Extensible Internet with Network Address Translation(AEIP NAT)
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Abstract

The two key issues of today's Internet are autonomy and extensibility. Autonomous Internet(AIP) technology can provide extensible internet architecture, own independent root DNS servers and self management internet network; Furthermore, based on the Autonomous Internet, here provides a way with extensible address capacity to solve IP address deficiency and realize Autonomous Extensible Internet(AEIP). It mainly adopts local network address based on per Autonomous IP network and uses bilateral dynamic NAT with global network address between Autonomous IP networks to solve IP address deficient problem. This AEIP with Network Address Translation(AEIP NAT) can realize autonomy and extensibility with minimal cost.

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1. Introduction

Internet has become an important strategic resource for its rapid development all over the world. Therefore, to solve the two key issues of Internet, autonomy and scalability, are particularly important.

The essence of Internet autonomous problem is to solve the domain name problem, so as to provide extensible architecture, provide multi-polar, self-control, self-management over the Internet, own independent root domain name server in each autonomous internet (AIP) network, and safeguard global Internet without quarrel.

The essence of Internet scalability problem is to solve the IP address shortage problem. Private network solution, dynamic address assignment technology, VLSM technology and NAT technology proposed in the field can only slow down the speed of the IP address depletion. Due to slow progress and many unsolved problems, IPv6 can not timely solve the IP address shortage problem and meet the needs of rapid developing Internet. The huge demand of Internet encourages that people must seriously consider the scalability of the IP network in reality.

This article will discuss the IP network's scalability on the base of Autonomous Internet, so as to solve the current problems caused by IP address shortage, to realize the autonomy and extension of the Internet.

1.1. Specification of Requirements

In this document, several words are used to signify the requirements of the specification. These words are often capitalized. The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

2. Autonomous Internet Technology

Autonomous Internet(AIP) technology provides a way to own independent root domain name servers to realize Autonomous Internet without necessary to overturn the Internet infrastructure. It provides Internet global equality, free extension, and self-management.

According to the AIP autonomous DNS, the domain name hierarchy can be designed distributedly and provide each AIP network autonomy; Each AIP network has its root DNS servers, which are responsible for all the DNS resolution in this AIP network. Other DNS servers of this AIP network should point to these root DNS servers by default. Each AIP network is almost the same as the current Internet, and the internal domain name resolution and IP node communication have not any change. The only change is that the destination domain name need add domain name suffix of the destination AIP network when IP nodes communicate between different AIP networks. Domain node "www.yahoo.com" in network B is expressed as "www.yahoo.com.B" for its external domain name. So each AIP domain name hierarchy tree adds the top-level domain name "ex(i)", so as to map the other external AIP domain name hierarchy trees accessible from this AIP network. When ex(i)=B, it means that the other AIP network B is accessible from this AIP network. At the same time, each AIP network will add a kind of device called "AIP DNS gateway" to support domain name resolution between AIP networks.

3. Autonomous Extensible Internet (AEIP NAT)

Autonomous Extensible Internet(AEIP) is feasible not only in practice but also in technology. In practice, the communication traffic is relatively much smaller between different languages and cultures, and convergence of language and communication traffic brings the reality of Internet autonomy. In technology, AIP can deploy easily and cause the least change, provide security, autonomy and extension in architecture. AIP is distributed Internet architecture. This architectural distribution provides more choices and possibilities in solving IP address deficiency problem.

Hereinafter, a technology would be introduced to realize extensible Internet, which is so call Autonomous Extensible Internet with Network Address Translation (AEIP NAT). AEIP NAT, which is based on AIP architecture, mainly adopts local network address based on per Autonomous IP network and uses bilateral dynamic NAT with global network address between Autonomous IP networks to solve IP address deficient problem.

3.1. Network Extensible Design

Autonomous Internet can solve the problem of Internet autonomy. Moreover, its distributed architecture design makes it extensible in architecture level. To increase the number of AIP network entities as need, we can realize the network extension. But the existing IP network address is almost used up. In further step, it is necessary to realize extension of the IP network address, so as to realize the extension of Internet indeed.

The realization method of extensible network address space is detailed as following:

First of all, the concept of the "Local Network Address (LNA)" is introduced inside each AEIP NAT network. The local network address resource (local IP address) within each AEIP NAT network includes considerable part of the Internet address space and can be duplicated in different AEIP NAT networks. In general, the network node can only be assigned local network address and all IP nodes within each AEIP NAT network can communicate to each other directly through the local network address. In this way, there are about several billions of IP address in each AEIP NAT network and it can solve the IP address deficient problem within each AEIP NAT network; Moreover, it can provide almost any needed IP address quantities if owning more AEIP NAT networks as need, which can increase the IP address quantity in times. To each AEIP NAT network such as A or B, it is almost consistent with the status of AIP network in Autonomous Internet and is not necessary to upgrade or change existing network node. The internal communication within each AEIP NAT is independent from other AEIP NAT networks.

Secondly, "Global Network Address (GNA)" (public IP address) is adopted to communicate between different AEIP NAT networks. The unique Global Network Address range between AEIP NAT networks is negotiated and planned globally (Under the special circumstance, it can be determined within the two AEIP NAT networks, which is communicating with each other). Different AEIP NAT networks will be allotted different GNA range. In each AEIP NAT network, DNS Gateway is responsible for the dynamic assignment of GNA. And it stores and maintains the GNA - LNA pairs table (G, L) and the domain name - GNA pairs table (N, G). Any GNA - LNA pair, for example (Ga, La), will be sent to NAT GW during its dynamical live period in order to translate address between the AEIP NAT networks. During its dynamic live period, any domain name - GNA pair, for example (Nb, Gb), will provide DNS GW domain name resolution and GNA query between AEIP NAT networks. So its smooth transition method is almost the same as Autonomous Internet except that upgrading the function of DNS GW and adding NAT GW device to support the NAT functions between AEIP NAT networks. In particular, if unilateral action is the only way available, the unilateral transformation method is the same as the method mentioned in AIP and mainly relates to external domain name between AEIP NAT networks. Due to only public IP address is legal between AEIP NAT networks before the existing Internet (the core part) can be transformed into one AEIP NAT network, so the existing Internet (the core part) does not need any transformation. Only in the new added AEIP NAT network, it needs to upgrade the function of DNS GW and add NAT GW device for cross-network address translation. The new added AEIP NAT network can adopt existing or reserved public IP addresses for cross-network communication. Thus the internal available IP addresses will increase greatly and achieve the extension of network.

In addition, the "Private Network Address" (PNA, namely existing private IP address) is still retained. It is used as private network address within each AEIP NAT network.

The realization of AEIP NAT is shown in Figure 1.

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                                .
+-------------------------------.-------------------------------+
|+---------+                    .                               |
||Root DNS <--------------------+                               |
||         |                    .\                              |
|+----^----+                    . +-----------------------+     |
|     |                         .                         |     |
|+----v----+                    .                    +----v----+|
||   DNS   |                    .                    |   DNS   ||
||  (.us)  |                    .                    |  (.cn)  ||
|+----^----+                    .                    +----^----+|
|     |                         .                         |     |
|+----v----+                    .                    +----v----+|
||  Host   |                    .                    |   Host  ||
|| N1(G1)  |                    .                    |  N2(G2) ||
|+---------+                    .                    +---------+|
|                            Internet                           |
+-------------------------------.-------------------------------+
                               \./
                                V
+------------------------------+ +------------------------------+
|+----------+     +-----------+| |+-----------+     +----------+|
|| Root DNS <----->  AEIP NAT <+-+>  AEIP NAT <-----> Root DNS ||
||   (A)    |     |  DNS GW A || ||  DNS GW B |     |   (B)    ||
|+----^-----+     |{(Na.A,Ga)}|| ||{(Nb.B,Gb)}|     +----^-----+|
|     |           +-----^-----+| |+----^------+          |      |
|+----v-----+           |      | |     |           +----v-----+|
||    DNS   |           |      | |     |           |    DNS   ||
||(.us/.com)|           |      | |     |           |(.cn/.com)||
|+----^-----+           |      | |     |           +----^-----+|
|     |            +----v-----+| |+----v-----+           |      |
|+----v-----+      | AEIP NAT || || AEIP NAT |      +----v-----+|
||   Host   <------>   GW A   <+-+>   GW A   <------>   Host   ||
|| Na1(La1) |      | {(Ga,La)}|| || {(Gb,Lb)}|      | Nb2(Lb2) ||
|+----------+      +----------+| |+----------+      +----------+|
|  Internet/AEIP NAT network A | |       AEIP NAT network B     |
+------------------------------+ +------------------------------+
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Figure 1: AEIP NAT realization

Note: IP host is labeled as DomainName(IPAddress). IP address with Prefix "L" such as "La" denotes LNA, IP address with prefix "G" such as "Ga" denotes GNA. AEIP NAT DNS GW is a gateway for DNS resolution between AEIP NAT networks and GNA assignment for its affiliated AEIP NAT network. AEIP NAT GW is a gateway for bilateral dynamic NAT between AEIP NAT networks.

3.2. Addressing Realization

Within each AEIP NAT network, IP nodes communicate to each other peer-to-peer directly adopting the Local Network Address.

Between different AEIP NAT networks, GNA will be adopted to locate the IP node in different network. Assume that there is any one IP node Na1(La1) in AEIP NAT network A, which has the domain name Na1 and local network address La1. And there is any one IP node Nb2(Lb2) in AEIP NAT network B, which has the domain name Nb2 and local network address Lb2. The communication process from Na1 to Nb2 is shown as following:

1) Source Address NAT Addressing Process:

It is required that the packet destination address adopts dynamic allocated GNA of specific destination AEIP NAT network, for example Gb2 for IP node Nb2.B (It can be obtained by DNS resolution between AEIP NAT networks). Thus the source node Na1 send a cross-network packet denoted as {S(La1),D(Gb2)}, which has a source address La1 and a destination address Gb2. Then this cross-network packet will be firstly routed to this source network's interworking gateway AEIP NAT GW A. And the AEIP NAT GW A will do network address translation to the source address in the cross-network packet. This source address NAT adressing process is detailed as following:

Step 1: the AEIP NAT GW A querys the source IP node's LNA(La1) corresponding record item in its GNA - LNA pairs table (G, L). If corresponding GNA - LNA pair record, for example (Ga1, La1), is return, the source network node's LNA(La1) in source address field of packet will be replaced by corresponding GNA(Ga1). And this packet, which is now denoted as {S(Ga1),D(Gb2)}, will be routed to the AEIP NAT GW B of the destination network. It is so called the source address NAT method.

Step 2: If the AEIP NAT GW A can not find the source IP node's LNA(La1) corresponding record item, for example (Ga1, La1), in its GNA - LNA pairs table (G, L). Then it will send a DNS PTR query to corresponding AEIP NAT DNS GW A in order to obtain the domain name of the soure IP node with LNA(La1):

(1) If the source node has a legal domain name, AEIP DNS GW A will act as an inner-network DNS agent, query and obtain source node's domain name and return it to AEIP NAT GW A in a traditional DNS resolution way. Then both of AEIP DNS GW A and AEIP NAT GW A have the source IP node's LNA(La1) corresponding record item (Na1, La1) in its domain name - LNA pairs table (N, L). At the same time, the source node is assigned GNA in the corresponding domain name - GNA pair record item (Na1.A, Ga1) inside AEIP NAT DNS GW A in order to be visited in cross-network access and receive the return ip packets. In addition, the GNA - LNA pair record item (Ga1, La1) is sent to the corresponding AEIP NAT GW A for NAT translation. And this GNA - LNA pair record item should keep consistent in AEIP NAT DNS GW A and in AEIP NAT GW A during its life time.

(2) If the source node does not have the legal domain name, AEIP NAT DNS GW A will assign it(local network address La1) a corresponding global network address Ga1. In addition, the GNA -LNA pair record item (Ga1,La1) is sent to the corresponding AEIP NAT GW A for NAT translation. And this GNA - LNA pair record item should keep consistent in AEIP NAT DNS GW A and in AEIP NAT GW A during its life time.

(3) Then the source network node's LNA(La1) in source address field of packet will be replaced by corresponding GNA(Ga1). And this packet, which is now denoted as {S(Ga1),D(Gb2)}, will be forwarded to the AEIP NAT GW B of the destination network.

2) Destination Address NAT Addressing Process:

The internetworking gateway AEIP NAT GW B in the destination AEIP NAT network B will have a destination address NAT to the destination address in cross-network data packet when the cross-network data packet reaches the AEIP NAT GW B in AEIP NAT network B. The process is detailed as following:

Step 3: the AEIP NAT GW B querys the destination IP node's GNA(Gb2) corresponding record item in its GNA - LNA pairs table (G, L). If corresponding GNA - LNA pair record, for example (Gb2, Lb2), is return, the destination network node's GNA(Gb2) in destination address field of packet will be replaced by corresponding LNA(Lb2). And this packet, which is now denoted as {S(Ga1),D(Lb2)}, will be forwarded into the AEIP NAT network B. It is so called the destination address NAT method. Finally, the packet will be routed and reach the destination node.

Step 4: If the AEIP NAT GW B can not find the destination IP node's GNA(Gb2) corresponding record item, for example (Gb2, Lb2), in its GNA - LNA pairs table (G, L). Then it will send a DNS PTR query to corresponding AEIP NAT DNS GW B in order to obtain the domain name of the destination IP node with GNA(Gb2):

(1) If the destination node has a legal domain name, it should be pre-assignned the corresponding domain name - GNA pair record item (Nb2.B, Gb2) inside AEIP NAT DNS GW B in order that the destination node can be visited in cross-network access and receive the return ip packets, and this would be return to AEIP NAT GW B for DNS query; At the same time, AEIP DNS GW B will act as a inner-network DNS agent, query and obtain destination node's domain name - LNA pair record and return it to AEIP NAT GW B in a traditional DNS resolution way. Then both of AEIP DNS GW B and AEIP NAT GW B have the destination IP node's corresponding record item (Nb2, Lb2) in its domain name - LNA pairs table (N, L). In addition, AEIP NAT DNS GW B will send the GNA - LNA pair record item (Gb2, Lb2) to the corresponding AEIP NAT GW B for NAT translation. And this GNA - LNA pair record item should keep consistent in AEIP NAT DNS GW B and in AEIP NAT GW B during its life time.

(2) If the destination node does not have a legal domain name, AEIP NAT DNS GW B should pre-assign it (local network address Lb2) a corresponding global network address Gb2 for cross-network communication. In addition, the GNA - LNA pair record item (Gb2-Lb2) is sent to the corresponding AEIP NAT GW B for NAT translation. And this GNA - LNA pair record item should keep consistent in AEIP NAT DNS GW B and in AEIP NAT GW B during its life time.

(3).Then AEIP NAT GW B would process the packet by the destination address NAT method. Here the destination network node's GNA(Gb2) in destination address field of packet will be replaced by corresponding LNA(Lb2) and this packet, which is now denoted as {S(Ga1),D(Lb2)}, will be forwarded into the AEIP NAT network B. Finally, the packet will be routed and reach the destination node.

3.3. DNS Resolution

Autonomous extensible internet AEIP NAT is evolved on the basis of autonomous internet AIP. Each autonomous IP network has a

complete set of domain name system to support the resolution of domain name and address within the network. Each network node has a default unique network domain name suffix whether is marked or not. The default unique network domain name suffix should be added while accessing to this external network node.

The AEIP NAT DNS gateway (AEIP NAT DNS GW) in each AEIP NAT network is evolved on the basis of AIP DNS GW to support cross-network DNS resolution between AEIP NAT networks. AEIP NAT DNS GW forwards the cross-network DNS query originated in this AEIP NAT network. And it provides and/or stores the dynamic assigned GNA for IP node in this AEIP NAT network. It responses with the corresponding dynamic assigned GNA for IP node in this AEIP NAT network to the cross-network DNS query originated in external AEIP NAT network.

The DNS resolution process is described as following:

Within each AEIP NAT network, the DNS resolution is the same a s the traditional way.

Between different AEIP NAT networks, when the source IP node originates a cross-network DNS resolution query, this query would be routed to this source network's AEIP NAT DNS GW A and then be forwarded to domain name affiliated destination network's AEIP NAT DNS GW B. The AEIP NAT DNS GW B in destination network would process this corss-network DNS query as following:

Step 1: First, the AEIP NAT DNS GW B will query whether there is corresponding domain name - GNA pair record item (Nb2.B, Gb2) in its record tables. If yes, AEIP NAT DNS GW B will return the record item (Nb2.B, Gb2) to the DNS requester and eventually it will reach the source IP node which originates the query.

Step 2: If the AEIP NAT GW B can not find the destination IP node's corresponding domain name record or domain name - GNA pair record item, for example (Nb2.B, Gb2), in its domain name - GNA pairs table (N, G), it will act as a inner-network DNS agent, query and obtain destination node's domain name - LNA pair record, for example (Nb2, Lb2) and return it to AEIP NAT GW B in a traditional DNS resolution way. At the same time, the destination node is assignned the corresponding domain name - GNA pair record item (Nb2.B, Gb2) inside AEIP NAT DNS GW B in order to be visited in cross-network access. AEIP NAT DNS GW B will return the record item (Nb2.B, Gb2) to the DNS requester and eventually it will reach the source IP node which originates the query. In addition, the GNA - LNA pair record item (Gb2, Lb2) is sent to the corresponding AEIP NAT GW B for NAT translation. And this GNA - LNA pair record item should keep consistent in AEIP NAT DNS GW B and in AEIP NAT

GW B during its life time.

4. Conclusion

The huge demand of Internet encourages that people must seriously consider the scalability of the IP network. So as to solve the two key issues of Internet, autonomy and scalability, are particularly important. Based on Autonomous Internet architecture, Autonomous Extensible Internet with Network Address Translation (AEIP NAT) mainly adopts local network address based on per Autonomous IP network and uses bilateral NAT with global network address between Autonomous IP networks to solve IP address deficient problem. It provides an integrated solution to Internet autonomy and extension issues. In practice, it has little reformation work, smooth transition and can be implemented even in unilateral technical action to realize Autonomous Extensible Internet.

5. Security Considerations

There is no additional security requirement than current Internet system. Security issues are not discussed in this memo.

6. IANA Considerations

According to the AEIP NAT solution and the design of the extensible address space, IANA need to plan proper ratio of GNA and LNA in 32-bit IP version 4 address capacity and adjust their assignment in different AEIP NAT networks.

7. Acknowledgments

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