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NAT64 Operational Experiences
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Abstract

This document summarizes stateful NAT64 deployment scenarios and operational experience with NAT64-CGN(NAT64 Carrier Grade NATs) and NAT64-CE (NAT64 Customer Edges).

Status of this Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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1. Introduction

Continued development of global Internet demands IP address consumption. The IANA global IPv4 address pool was exhausted on February 3, 2011. IPv6 is the only sustainable solution for numbering nodes on the Internet. Network operators have to deploy IPv6 networks in order to meet the numbering needs of the expanding internet without available IPv4 addresses. IPv4 numbering resources and IPv4-only schemes to reduce the numbering utilization during the transitional will not be adequate to maintain connectivity and deliver Internet services.

As IPv6 deployment continues, IPv6 networks and hosts will need to coexist with IPv4 numbered resources. The Internet will include nodes that are Dual-stack, nodes that remain IPv4-only and IPv6-only nodes. It may be desirable in some cases for operators to deploy a single stack network, for reasons of simplicity, cost or performance relative to a dual stack network. As IPv4 utilization eventually declines, the appeal of single stack network deployments will likely increase. In a dual-stack architecture, operators have to maintain double management interfaces, provide operational support systems for two networks, track multiple addresses in different families per host, trouble shoot host behavior related to dual stack operation and engage in other activities that increase the overhead of operating the network.

Single stack IPv6 network deployment can simplify the network provisioning. Some justification has been described in [I-D.ietf-v6ops-464xlat]. IPv6-only networks confer some benefits to mobile operators employing them. In the mobile context, it enables the use of a single IPv6 PDP(Packet Data Protocol), which eliminates significant network cost caused by doubling the PDP count on a mass of legacy mobile terminals. In broadband networks overall, it can allow for the scaling of edge-network growth decoupled from IPv4 numbering limitations.

In a transition scenario, an existing network may rely on the IPv4 stack for a long time. There is also the troublesome trend of access network providers squatting on IPv4 address space that they do not own. Allowing for interconnection between IPv4-only nodes and IPv6-only nodes is a critical capability. Widespread dual-stack deployments have not materialized at the anticipated rate over the last 10 years on possible conclusion being that legacy networks will not make the jump quickly. A translation mechanism based on a NAT64[RFC6146] function might be a key element of the internet infrastructure supporting such legacy networks.

[RFC6036] reported at least 30% operators plan to run some kind of

translator (presumably NAT64/DNS64). Advice on NAT64 deployment and operation is therefore of some importance. [RFC6586] documented the implications for ipv6 only networks. This document intends to be specific to NAT64 network planning.

In regards to IPv4/IPv6 translation, [RFC6144] has described a framework of enabling networks to make interworking possible between IPv4-only and IPv6-only networks. Three scenarios are described, "An IPv6 Network to the IPv4 Internet", "The IPv6 Internet to an IPv4 Network" and "An IPv6 Network to an IPv4 Network" where a NAT64 function is relevant. The scenario of "The IPv6 Internet to the IPv4 Internet" seems to be the ideal case for inter-network translation technology. This document has focused on the three cases and further categorized different NAT64 location and use case. The principle distinction of location is if the NAT64 is located in a NAT64-CGN (Carrier Grade NATs) or NAT64-CE (Customer Edges). NAT64-CGN corresponds to the scenario "IPv6 Network to IPv4 Internet". The NAT64-CE location roughly corresponds to the "IPv6 Internet to IPv4 Network" and "IPv6 Network to IPv4 Network" scenarios. Based on different NAT64 modes, different considerations have been described for ISPs to facilitate NAT64 deployments.

2. Terminology

The terms of NAT-CGN/CE are understood to be a topological distinction indicating different features employed in a NAT64 deployment.

NAT64-CGN: A NAT64-CGN (Carrier Grade NATs) is placed in an ISP network and managed by an administrative entity, e.g. operator. From an administrator view, a NAT64-CGN usually forwards outbound traffic into an IPv4 network. IPv6 only subscribers leverage the NAT64-CGN to be served by existing IPv4 internet services. The ISP as an administrative entity takes full control on the IPv6 side, but has limited or no control on the IPv4 side. ISP's should attempt to accommodate the behavior of IPv4 networks and services.

NAT64-CE: A NAT64-CE (Customer Edges) is placed at the edge of customer network, e.g. a network operated by an Enterprise or Consumer. A NAT64-CE makes IPv4 services accessible for the IPv6 only users. An upstream entity and ISP usually operates an IPv4 and potentially IPv6 network respectively. IPv6 access is the common infrastructure behind the NAT64-CE.

3. NAT64-CGN Deployment Experiences

A NAT64-CGN deployment scenario is depicted in Figure 1

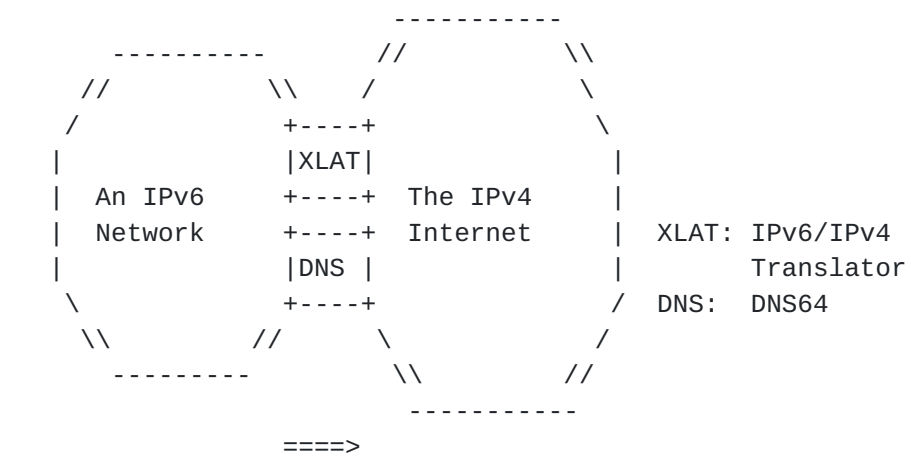

Figure 1: NAT64-CGN Scenario: IPv6 Network to IPv4 Internet

3.1. NAT64-CGN Networking

The NAT64-CGN use case is employed to connect IPv6-only users to the IPv4 Internet. The NAT64 gateway performs protocol translation from an IPv6 packet header to an IPv4 packet header and vice versa according to the Stateful NAT64 [RFC6146]. Address translation maps IPv6 addresses to IPv4 addresses and vice versa for return traffic.

All connections to the IPv4 Internet from IPv6-only clients must traverse the NAT64-CGN. It is advantageous from the vantage-point of troubleshooting and traffic engineering to carry the IPv6 traffic natively for as long as possible within an access network and translates only at or near the network egress.

In mobile networks, various possibilities can be envisaged in which to deploy the NAT64 function. Whichever option is selected, the NAT64 function will be deployed beyond the GGSN (Gateway GPRS Support Node) or PDN-GW (Public Data Network-Gateway), i.e. first IP node in currently deployed mobile architectures.

In a given implementation, NAT64 functionality can be provided by either a dedicated GW device or an multifunction gateway with integrated NAT64 functionality. In standalone NAT64, NAT64-CGN is placed to the side of a BNG or CR. An embedded NAT64 deployment would be integrated with an existing GW. Capacities of an existing GW can be potentially limited by the inserted functionality. In a mobile context, the NAT64 function can be co-located with GGSN/PDN-GW

or it can be embedded in an existing FW/NAT44 already deployed in support of IPv4 NAT or, the function can be collocated on a router. Whatever the solution retained for the co-location option, impact on existing services and legal obligations have to be assessed.

3.2. High Availability Considerations

High Availability (HA) is a major requirement for every service and network service.

Two mechanisms are typically used to achieve high availability, i.e. cold-standby and hot-standby. Cold-standby systems have synchronized configuration and mechanism to failover traffic between the hot and cold systems such as VRRP [RFC5798] . Unlike hot-standby, cold-standby does not synchronize NAT64 session state. This makes cold-standby less resource intensive and generally simpler, but it requires clients to re-establish sessions when a fail-over occurs. Hot-standby has all the features of cold-standby but must also synchronize the binding information base (BIB). Given that short lived sessions account for most of the bindings, hot-standby does not offer much benefit for those sessions. Consideration should be given to the importance (or lack thereof) of maintaining bindings for long lived sessions across failovers.

3.3. Traceability

Traceablility is required in many cases to identify an attacker or a host that launches malicious attacks and/or for various other purposes, such as accounting requirements. NAT64 devices are required to log events like creation and deletion of translations and information about the occupied resources. There are two different demands for traceability,i.e. online or offline.

- Regarding the Online requirements, XFF (X-Forwarded-For) [I-D.ietf-appsawg-http-forwarded]would be a candidate, it appends IPv6 address of subscribers to HTTP headers which is passed on to WEB servers, and the querier server can lookup radius servers for the target subscribers based on IPv6 addresses included in XFF HTTP headers. X-Forwarded-For is specific to HTTP, requires the use of an application aware gateway, cannot in general be applied to requests made over HTTPs and cannot be assumed to be preserved end-to-end as it may be overwritten by other application-aware proxies such as load balancers.

- Some potential solutions to online traceability are explore in [I-D.ietf-intarea-nat-reveal-analysis].

- A NAT64-CGN could also deliver NAT64 sessions (BIB and STE) to a Radius server by extension of the radius protocol. Such an extension is an alternative solution for online traceability, particularly high performance would be required on Radius servers on order to achieve this.

- For off-line traceability, syslog might be a good choice. [RFC6269] indicates address sharing solutions generally need to record and store information for specific periods of time. A stateful NAT64 is supposed to manage one mapping per session. A large volume of logs poses a challenge for storage and processing. In order to mitigate the issue, [I-D.donley-behave-deterministic-cgn]proposed to pre-allocated a group of ports for each specific IPv6 host. A trade-off among address multiplexing efficiency, port randomization security[RFC6056] and logging storage compression should be considered during the planning. A hybrid mode combining deterministic and dynamic port assignment was recommended regarding the uncertainty of user traffic.

3.4. Quality of Experience

NAT64 is providing a translation capability between IPv6 and IPv4 end-nodes. In order to provide the reachability between two IP address families, NAT64-CGN has to implement appropriate ALGs where address translation is not itself sufficient and security mechanisms do not render it infeasible. e.g. FTP-ALG[RFC6384], RSTP-ALG, H.323-ALG,etc. It should be noted that ALGs may impact the performance on a NAT64 box to some extent. ISPs as well as content providers might choose to avoid situations where the imposition of an ALG might be required. At the same time, it is also important to remind customers that IPv6 end-to-end usage does not require ALG imposition and therefore results in a better overall user experience.

The service experience should be optimized around stateful NAT processing. Session status normally is managed by a static life-cycle. In some cases, NAT resource maybe significantly consumed by largely inactive users. The NAT translator and other customers would suffer from service degradation due to port consummation by other subscribers using the same NAT64 device. A flexible NAT session control is desirable to resolve the issues. PCP[I-D.ietf-pcp-base] could be a candidate to provide such capability. A NAT64-CGN should integrate with a PCP server, to allocate available IPv4 address/Port resources. Resources could be assigned to PCP clients through PCP MAP/PEER mode. Such an ability should also be considered to upgrade user experiences, e.g. assigning different sizes of port ranges for different subscribers. Such a mechanism is also helpful to minimize terminal battery consumption reducing the number of keepalive

messages to be sent by terminal devices.

3.5. Load Balancer

Load balancers are an essential tool to avoid the issue of single points of failure and add additional scale. It is potentially important to employ load-balancing considering that deployment of multiple NAT64 devices. Load balancers are required to achieve some service continuity and scale for customers. [I-D.zhang-behave-nat64-load-balancing] discusses several ways of achieving NAT64 load balancing, including anycast based policy and prefix64 selection based policy, either implemented via DNS64[RFC6147] or Prefix64 assignments. Since DNS64 is normally co-located with NAT64 in some scenarios, it could be leveraged to perform the load balance. For traffic which does not require a DNS resolution, prefix64 assignment based on[I-D.ietf-behave-nat64-learn-analysis] could be adopted.

3.6. MTU Consideration

IPv6 requires that every link in the internet have an MTU of 1280 octets or greater[RFC2460]. However, in case of NAT64 translation deployments, some IPv4 MTU constrained link will be used in some communication path and originating IPv6 nodes may therefore receive an ICMP Packet Too Big message, reporting a Next-Hop MTU less than 1280. The result would be that IPv6 allows packets to contain a fragmentation header, without the packet being fragmented into multiple pieces. [I-D.ietf-6man-ipv6-atomic-fragments] discusses how this situation could be exploited by an attacker to perform fragmentation-based attacks, and also proposes an improved handling of such packets. It required enhancements on protocol level, which might imply potential upgrade/modifications on behaviors to deployed nodes. Another approach that potentially avoids this issue is to configure IPv4 MTU>=1260. It would forbid the occurrence of PTB<1280. However, such an operational consideration is hard to universally apply to the legacy "IPv4 Internet".

4. NAT64-CE Deployment Experiences

The NAT64-CE Scenario is depicted in Figure 2

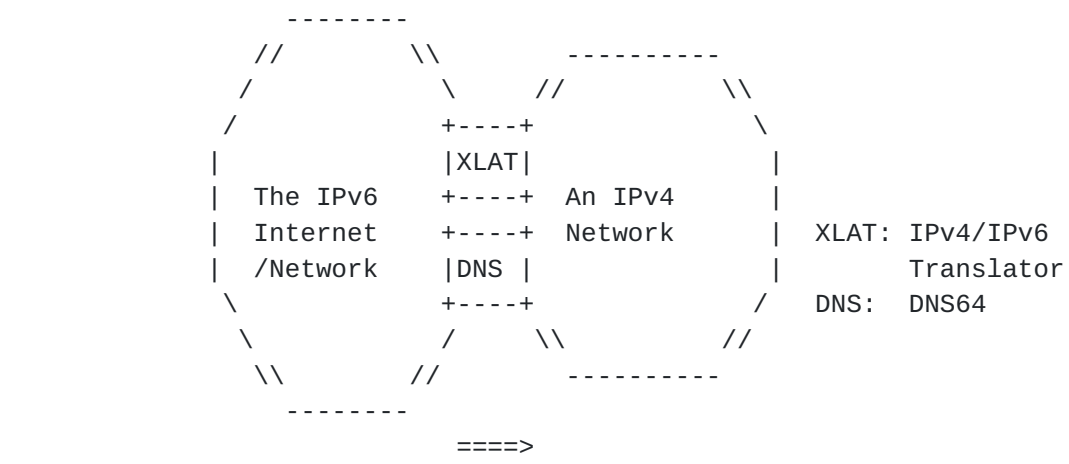

Figure 2: NAT64-CE Scenario: IPv6 Internet/Network to IPv4 Network

4.1. NAT64-CE Networking

Content providers would like to use IPv6 to serve customers since it allows for the definition of new services without having to integrate consideration of IPv4 NAT and address limitations of IPv4 networks, but they have to provide some IPv4 service continuity to their customers. In some cases, customers outside the network will have IPv6-only access provided by early adopters before the internal network. The deployment requirements could be resolved by subsiding NAT64 to a customer edge. [I-D.ietf-v6ops-icp-guidance] has described the cases, in which an HTTP proxy can readily be configured to handle incoming connections over IPv6 and to proxy them to a server over IPv4. Those cases are sure to exist for the time being. An administrator of the IPv4 network needs to be cautious and aware of the operational issues this may cause, since the native IPv6 is always more desirable than transition solution.

One potential challenge in the scenario is NAT64-CE facing IPv6 Internet, in which a significant number of IPv6 users may initiate connections. When increasingly numerous users in IPv6 Internet access an IPv4 network, scalability concerns(e.g. additional latency, a single point of failure, IPv4 pool exhaustion, etc) are apt to be applied. For a given off-the-shelf NAT64-CE, those challenges should be seriously assessed. Potential issues should be properly identified.

For operators who seek a clear precedent for operating reliable IPv6-only services, it should be well noted that the usage is problematic at several aspects. In some sense, it's not recommended.

4.2. Anti-DDoS/SYN Flood

For every incoming new connection from the IPv6 Internet, the NAT64-CE creates state and maps that connection to an internally-facing IPv4 address and port. An attacker can consume the resources of the NAT64-CE device by sending an excessive number of connection attempts. Without a DDOS limitation mechanism, the NAT64 is exposed to attacks from the IPv6 Internet. With service provisioning, attacks have the potential could also deteriorate service quality. One consideration in internet content providers is place a L3 load balancer with capable of line rate DDOS defense, such as the employment of SYN PROXY-COOKIE. Security domain division is necessary in this case. Load Balancers could not only serve for optimization of traffic distribution, but also serve as a DOS mitigation device

4.3. User Behavior Analysis

IP addresses are usually used as input to geo-location services. The use of address sharing will prevent these systems from resolving the location of a host based on IP address alone. Applications that assume such geographic information may not work as intended. The possible solutions listed at section 3.3 intended to bridge the gap. However, the analysis reveals those solutions can't be a optimal substitution to solve the problem of host identification, in particular it does not today mitigate problems with source identification through translation. That makes NAT64-CE usage becoming a unappealing approach, if customers require source address tracking.

For the operators, who already deployed NAT64-CE approach, the source address of the request is obscured without the source address mapping information previously obtained. It's superior to present mapping information directly to applications. Some application layer proxies e.g. XFF (X-Forwarded-For) , can convey this information in-band. Another approach is to ask application coordinating the information with NAT logging. But that is not sufficient, since the applications itself wants to know the original source address from an application message bus. The logging information may be used by administrators offline to inspect use behavior and preference analysis, and accurate advertisement delivery.

4.4. DNS Resolving

In the case of NAT64-CE, it is recommended to follow the recommendations in [RFC6144]. There is no need for the DNS to synthesize AAAA from A records, since static AAAA records can be registered in the authoritative DNS for a given domain to represent

these IPv4-only hosts. How to design the FQDN for the IPv6 service is out-of-scope of this document.

4.5. Load Balancer

Load balancing on NAT64-CE has a couple of considerations. If dictated by scale or availability requirements traffic should be balanced among multiple NAT64-CE devices. One point to be noted is that synthetic AAAA records may be added directly in authoritative DNS. load balancing based on DNS64 synthetic resource records may not work in those cases. Secondly, NAT64-CE could also serve as the load balancer for IPv4 backend servers. There are also some ways of load balance for the cases, where load balancer is placed in front of NAT64(s).

4.6. MTU Consideration

As compared to the MTU consideration in NAT64-CGN, the MTU of IPv4 network are strongly recommended to set to more than 1260. Since a CE IPv4 network is normally operated by a particular administrative entity, it should take steps to prevent the risk of fragmentation discussed in [I-D.ietf-6man-ipv6-atomic-fragments].

5. Security Considerations

This document presents the deployment experiences of NAT64 in CGN and CE scenario, some security considerations are described ib detail regarding to specific NAT64 mode in section 2 and 3. In general, RFC 6146[RFC6146] provides TCP-tracking, address-dependent filtering mechanisms to protect NAT64 from DDOS. In NAT64-CGN cases, ISP also could adopt uRPF and black/white-list to enhance the security by specifying access policies. for example, NAT64-CGN should forbid establish NAT64 BIB for incoming IPv6 packets if URPF (Strict or Loose mode) check does not pass or whose source IPv6 address is associated to black-lists.

6. IANA Considerations

This memo includes no request to IANA.

7. Acknowledgements

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