Migrating residential services to IPv6
Solving IPv4 address space exhaustion with Nokia service routers

- Achieve an orderly and phased transition of IPv6 into the services network
- Solve IPv4 address space exhaustion issues during the transition period

The Nokia residential service delivery solutions facilitate both conservative and aggressive IPv6 migration strategies. To ease the migration to IPv6, the Nokia IP routing platforms natively support IPv6 and dual stack IPv4/IPv6 services and also provide other features to ease the migration. IPv4 continuity features extend the lifetime of IPv4 addresses and mitigate IPv4 exhaustion issues during the migration to IPv6. IPv6 transition features allow IPv6 services to be introduced in a controlled, phased manner with minimal impact on existing services.

Complementary deployment options for migrating residential services to IPv6 are available on both the Nokia Virtualized Service Router (VSR) and the Nokia 7750 Service Router (SR). These platform options provide the deployment flexibility needed for the cloud era, with consistent feature capabilities such as the Carrier Grade Network Address Translation (CG-NAT) and Broadband Network Gateway (BNG) functions as Virtualized Network Functions (VNF) or physical network appliances. This flexibility gives service providers the opportunity and choice to implement IPv6 migration strategies in an evolutionary manner while balancing cost, scaling, performance and time-to-market objectives.

Overview
To cope with IPv4 exhaustion, service providers basically have two strategies:
1. IPv6 transition, where IPv6 is introduced into the network while maintaining IPv4 services and connectivity; and
2. IPv4 continuity, using network address translation (NAT) techniques to manage IPv4 address exhaustion by overloading the IPv4 address space.

The Nokia IP service solutions supports several different types of CG-NAT, also referred to as large-scale NAT (LS-NAT), as well as different IPv6 transition techniques to introduce IPv6 into the network while maintaining continuity of IPv4 services.

IPv6 is gradually gaining wide-scale deployment and acceptance in private clouds and on the internet. However, IPv4 services will still be needed for a long time until the migration to IPv6 is complete. Dual stack IPv4/IPv6 services are also needed during the transition period for accessing both IPv4 and IPv6 servers for information, commerce and entertainment.

For service providers evolving to a Network Functions Virtualization (NFV) infrastructure, CG-NAT is considered a very sensible function to virtualize because it is seen as a temporary solution. By virtualizing it, once the migration to IPv6 is complete, the underlying platform resources can be reclaimed for other applications.
Components

CG-NAT is a network-based network address and port translation (NAPT) function for IPv4 that is highly available, can scale to millions of simultaneous sessions, track customer connections, enforce per-subscriber session limits, and can support Lawful Intercept (LI) to allow law enforcement action against individual subscribers. The NAPT of an IPv4 address that is translated to another IPv4 address is referred to as NAT44 which allows the service provider to map multiple subscribers to a single IPv4 public address at the service provider’s internet gateway (see Figure 1).

Layer 2-aware NAT, with delimiter options for Internet Protocol over Ethernet (IPoE), Point-to-Point Protocol over Ethernet (PPPoE) and Layer 2 Tunneling Protocol (L2TP), is an IPv4 NAT solution developed by Nokia that allows many residential subscribers to use the same IP address by integrating a NAT/NAPT component into the BNG (see Figure 2). Because the BNG maintains subscriber context, the subscriber ID is used as a unique identifier for all NAT sessions.

Subscriber-aware NAT is NAT for cases when the Nokia VSR and 7750 SR act as a standalone, centralized NAT behind BNGs that terminate subscribers (see Figure 3). The subscriber-aware NAT component acts as a RADIUS proxy to determine subscriber context for the NAT mappings.

Subscriber-aware NAT is similar in concept to Layer 2-aware NAT, but subscriber-aware NAT allows for centralizing the NAT function because the NAT and BNG are in separate service routers, whereas with Layer 2-aware NAT, the NAT and BNG are in a single Nokia IP router performing both functions.

Figure 1. CG-NAT

Figure 2. Layer 2-aware NAT
Dual Stack Lite (DS-Lite) allows IPv4 services to traverse an IPv6-only access network. DS-Lite defines a Basic Bridging Broadband (B4) element that resides in the customer home gateway and encapsulates IPv4 payload in IPv6 to be extracted by an Address Family Transition Router (AFTR) element in the Nokia VSR and 7750 SR (see Figure 4). As the name implies, DS-Lite allows for dual stack IPv4/IPv6 residential services by tunneling the IPv4 services through the IPv6-only access network, whereas IPv6 services are supported natively in the IPv6 access network.

NAT64 allows IPv6 hosts to communicate with IPv4 servers (see Figure 5). NAT64 requires a complementary Domain Name Server (DNS64) function to enable IPv6 clients to interoperate with IPv4 hosts. NAT64 can be a potential intermediate step in the IPv4 to IPv6 evolution for a service provider to address the need to access IPv4 content when the access network is completely IPv6 capable.

Dual stack IPv4/IPv6 BNG functionality is supported on Nokia VSR and 7750 SR and allows subscribers to have access to both IPv4 and IPv6 servers. Nokia is a contributor to the Broadband Forum documents defining the transition to IPv6 residential broadband services (TR-177 and TR-187) for PPP, L2TP and IPoE. A dual stack residential subscriber will have both IPv4 and IPv6 traffic within a single subscriber context and subscriber profile on the BNG.
The Nokia advantage

Nokia IP routing solutions enable a cost-effective, graceful migration to IPv6 for residential services that offer several benefits:

- Wide variety of IPv4 continuity and IPv6 transition tools and approaches to best fit the service provider's desired transition timeline and approach
- IPv6 transition mechanisms to introduce IPv6 and its services into the network while maintaining IPv4 interoperability
- Comprehensive IPv4, IPv6 and dual stack IPv4/IPv6 BNG capabilities with concurrent support of full service routing features for improved operational efficiency and reduced costs

Furthermore, the Nokia VSR and 7750 SR IP routing platforms run the widely deployed Nokia Service Router Operating System (SR OS) and are managed by a common network and service management system. These capabilities enable seamless operations between virtual and physical environments. For more information, visit the Nokia VSR and 7750 SR website.

### Features

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<th>Feature</th>
<th>Benefit</th>
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<tr>
<td>CG-NAT44</td>
<td>Extends the life of IPv4 address space by allowing service providers to incorporate NAT with service provider scale</td>
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<td>Layer 2-aware NAT</td>
<td>Integrated NAT and BNG functionality in a single router where the NAT is keyed to the subscriber identification so all subscribers can use the same IP address</td>
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<tr>
<td>Subscriber-aware NAT</td>
<td>NAT in a standalone router that acts as a RADIUS proxy to correlate NAT mappings to subscribers terminated on separate BNGs</td>
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<td>Port Control Protocol (PCP)</td>
<td>IETF protocol that allows a home gateway to communicate with a service provider NAT to facilitate incoming connections</td>
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<td>NAT64</td>
<td>Allows an IPv6 client to communicate with an IPv4 server so IPv6 services can be introduced while maintaining IPv4 compatibility</td>
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<td>NAT redundancy</td>
<td>Enables NAT services to be deployed in redundant pairs, ensuring that NAT is highly available</td>
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<tr>
<td>DS-Lite AFTR</td>
<td>Allows the introduction of dual stack IPv4/IPv6 services over an IPv6-only access network</td>
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<td>IPv4/IPv6 dual-stack residential services</td>
<td>Ties together IPv4 and IPv6 services within a single subscriber context with a common policy for quality of service (QoS), accounting and so on</td>
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