



DS-LITE

IPv6 Dual-Stack lite (DS-Lite) is part of the Benu Networks' family of Virtual Service Edge (VSE) IPv4-IPv6 transition solutions that allows broadband service providers to transition to IPv6 without impacting existing subscriber's use of IPv4 Internet and applications. The Benu Networks' DS-Lite solution provides a standards-based Address Family Transition Router (AFTR) capability per IETF RFC6333 that can be deployed in a virtualized instance (VMware, OpenStack) or integrated with Benu high-performance compute nodes.

The IPv4 Address Challenge

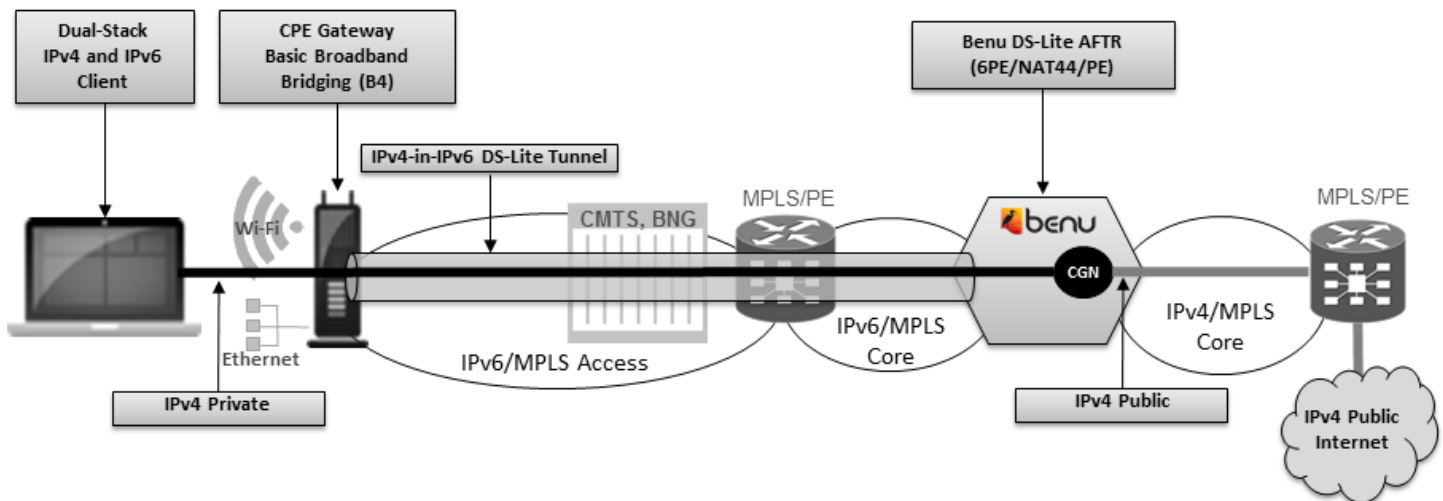
Technology consulting firm Gartner predicts the number of connected devices in use will reach 20.8 billion by 2020, up from 6.4 Billion in 2016. The growth of IP-connected devices has caused a rapid depletion of IPv4 addresses globally. On September 24, 2015, the American Registry for Internet Numbers (www.ARIN.net) issued the final IPv4 addresses in their free pool. The other four Regional Internet Registries (RIR) are rapidly depleting their limited IPv4 pools. Globally, IPv4 remains the predominant Internet traffic protocol to IPv6, but IPv6 adoption is accelerating according to Akamai's State of the Internet report Q3 2016. The same report also notes most advanced markets have a higher mix of IPv6 traffic than emerging markets but IPv4 still is a greater percentage. IPv4 is not compatible with IPv6 and therefore most devices are required to support dual-stack (IPv4 and IPv6) clients so content can be accessed in both protocols. For some years now, Internet Service Providers have been allocating a public IPv4 address per subscriber, which is not sustainable due to the growth in broadband subscribers. Additionally, upgrade and maintenance of a dual-stack (IPv4 and IPv6) network with continued traffic growth exceeding 50% CAGR, is too complex and CAPEX intensive. A transition to an all IPv6 solution is needed while supporting legacy IPv4 clients and IPv4 Internet.

DS-Lite Overview

DS-Lite is one of the IPv6 transition mechanisms implemented in the Benu Networks' Virtual Service Edge (VSE). DS-Lite is an IPv6 transition solution for ISPs with IPv6 infrastructure to connect their IPv4 subscribers to the IPv4 Internet. DS-Lite is a standards-based technology defined by Internet Engineering Task Force (IETF) in RFC6333 and leverages two well-known technologies: IP in IP (IPv4-in-IPv6) and Carrier-Grade Network Address Translation (CGNAT). DS-Lite is implemented in the customer premise equipment (CPE) and in an IP core network router. The core network router is referred to as the Address Family Transition Router (AFTR). The DS-Lite function in the CPE is referred to as the Basic Broadband Bringing (B4) function. Important broadband standards organizations such as CableLabs <http://www.cablelabs.com/> and Broadband Forum www.broadband-forum.org have validated DS-Lite a favorable migration strategy for IPv4 to IPv6 transition. DS-Lite will enable both continued support for IPv4 services and easier transition to the deployment of IPv6.

Key benefits for ISP deploying DS-Lite are as follows:

- DS-Lite is a proven technology widely available in broadband CPE (e.g. Cable Modems, xDSL Modems), and is readily available to ISPs
- DS-Lite provides dual-stack to users without requiring any public IPv4 address assigned to the CPE thus streamlining deployment and management of IPv4
- DS-Lite uses IPv6 in the access network to ease the IPv4 exhaustion issue, simplifying management of access network
- Native IPv6 traffic can be supported in the ISP core network, promoting adoption of IPv6



In the DS-Lite architecture, the CPE (B4) element encapsulates native IPv4 traffic in the IPv6 tunnel (soft-wire) which is terminated on the Benu AFTR function. The AFTR function is an integrated part of Benu Operating System (BenuOS), which provides additional IP network services such as Provider Edge routing, MPLS, H-QoS, ACLs and other important functionality critical for large scale deployment. The AFTR function can be deployed in a virtual (VMware or OpenStack) environment or deployed on Benu Networks integrated x86 compute nodes. The VSE platform supports carrier-class capabilities to meet the most demanding requirements.

Key highlights of the Benu Networks AFTR service offering are:

- Large scale aggregation of IPv4-in-IPv6 soft-wires
- Carrier-Grade NAT (CGN) and CGN logging for deterministic NAT service delivery
- Advanced Provider Edge routing MP-BGP/6PE/MPLS for better network integration
- Advanced DPDK fast path capabilities for scale and performance
- Support platform evolution to multi-service SDN architecture for next generation programmable network and service delivery

Benu Networks operating system BenuOS has been deployed at scale in some of the largest ISPs in the world providing reliable and scalable IP subscriber management, carrier-grade NAT, policy enforcement, core routing and mobility. When deployed in a virtualized environment the actual scale and performance will depend on server platform and specific virtualization environment. Optionally, Benu Networks provides pre-integrated and certified compute nodes to provide predictable scale and performance. AFTR performance for integrated compute nodes solutions from Benu Networks are as follows:

xMEG Product	Performance Guideline*
980-0011 980-0012	xMEG-100 Platform with 2x100GE QSFP28 Throughput: 200 Gb/s Capacity, 100 Gb/s Full Duplex Assuming 1 Mbps Full Duplex per B4 CPE Concurrent B4 DS-Lite Tunnels: 100,000 Concurrent IPv4 Sessions: 400,000 CGN Bindings: 204 Million
980-0009 980-0010	xMEG-100 Platform with 8x100GE SFP+ Throughput: 200 Gb/s Capacity, 100 Gb/s Full Duplex Assuming 1 Mbps Full Duplex per B4 CPE Concurrent B4 DS-Lite Tunnels: 100,000 Concurrent IPv4 Sessions: 400,000 CGN Bindings: 204 Million
*Actual performance will vary depending on deployment environment and traffic model.	

BenuOS

BenuOS provides carrier-grade IP networking feature set to solve today’s most complex IP service delivery challenges to maximize the customer lifetime value of business, residential and mobile subscribers. In addition to key AFTR features, BenuOS supports multi-service routing and gateway functions for fixed and mobile applications.

Feature Details*

High Performance, Scalable Platform	Virtualization	Networking
<ul style="list-style-type: none"> BenuOS(Operating System) Multi-core Support Linear Application Scaling Carrier Grade Linux DPDK data plane 10GE or 100GE Interface support 	<ul style="list-style-type: none"> Virtual Appliance for VMware vSphere ESXi 5.5 and later Virtual Appliance for Open-Stack (Liberty or greater) 	<ul style="list-style-type: none"> Routing – Static Routes, IS-IS (v4/v6), RIPv2, OSPF v2, BGP4/BGP6, IBGP Virtual Router Function (VRF) MP-BGP, MPLS, 6PE VLAN Support Access Control Lists (ACLs)
DS-Lite AFTR Features	Management	
<ul style="list-style-type: none"> Carrier Grade NAT (CGN/CGNAT), Large Scale NAT (LSN) Multiple port-block allocations Fragmentation support (both IPv4 and IPv6) CGN logging CGN logging to RADIUS 	<ul style="list-style-type: none"> Dedicated Management Interface (Console, SSH, IPMI) Industry standard Command Line Interface (CLI) SNMP, Syslog, Alerting Port mirroring RADIUS attributes in logs Policy from RADIUS 	

*Features may vary based on application and deployment model

Products Supported

The vMEG product is BenuOS supported in a virtual solution environment with VMware or OpenStack. Minimum requirements for vMEG are available in the table below.

vMEG Product	Description
700-1310	vMEG BenuOS VMware 12 Core Capacity License Minimum Requirement: VMware vSphere ESXi 5.5 and later, 6 Core Intel Haswell-class CPU or greater, 24GB memory, 20GB of SSD.
700-1320	vMEG BenuOS OpenStack 12 Core Capacity License Minimum Requirement: OpenStack Liberty (or greater), 6 Core Intel Haswell-class CPU or greater, 24GB memory, 20GB SSD.

The xMEG product is Benu Networks' integrated compute node offering for service providers that prefer to deploy a network appliance model. This is the same BenuOS without virtualization in a fully integrated and supported x86 compute platform. The following xMEG hardware configurations are available.

xMEG Product	Description
980-0012	xMEG100-DC 2x100GE QSFP28, 2RU (19" Rack) Average Power BTU: 400 W 1365 BTU/hr. Max Power BTU: 1100 W 4,100 BTU/hr.
980-0011	xMEG100-AC 2x100GE QSFP28, 2RU (19" Rack) Average Power BTU: 375 W 1365 BTU/hr. Max Power BTU: 1100 W 4,100 BTU/Hr.
980-0010	xMEG100-DC 8x10GE SFP+ Ports, 2RU (19" Rack) Average Power BTU: 450 W 1535 BTU/hr. Max Power BTU: 1100 W 4,100 BTU/Hr.
980-0009	xMEG100-AC 8x10GE SFP+ Ports, 2RU (19" Rack) Average Power BTU: 425 W 1450 BTU/hr. Max Power BTU: 1100 W 4,100 BTU/Hr.
980-0008	xMEG10-DC 4x1GE Copper plus 2x10GE SFP+ Ports, 1 RU (19" Rack) Average Power BTU: 175 W 597 BTU/hr. Max Power BTU: 1100 W 4,100 BTU/Hr.
980-0007	xMEG10-AC 4x1GE Copper plus 2x10GE SFP+ Ports, 1 RU (19" Rack) Average Power BTU: 150 W 512 BTU/hr. Max Power BTU: 750 W 2981 BTU/Hr.



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