BENU NETWORKS

Data Sheet

Virtual Broadband Network Gateway (vBNG)

The growth in demand for bandwidth and broadband services by wireline and wireless subscribers continues unabated and this will accelerate as the network evolves, 5G deployment expands, and edge use cases and services become more prevalent. New market trends are driving new requirements at the network edge (Figure 1).

How do network providers meet the evolving needs of their customers, the increased demand for specialized services, and do so with a technical and economic model that allows them to grow business and create shareholder value?

The answer is through transformation at the network edge, made possible by Benu's Virtual Broadband Network Gateway (vBNG) – part of Benu Network's SD-Edge Platform.

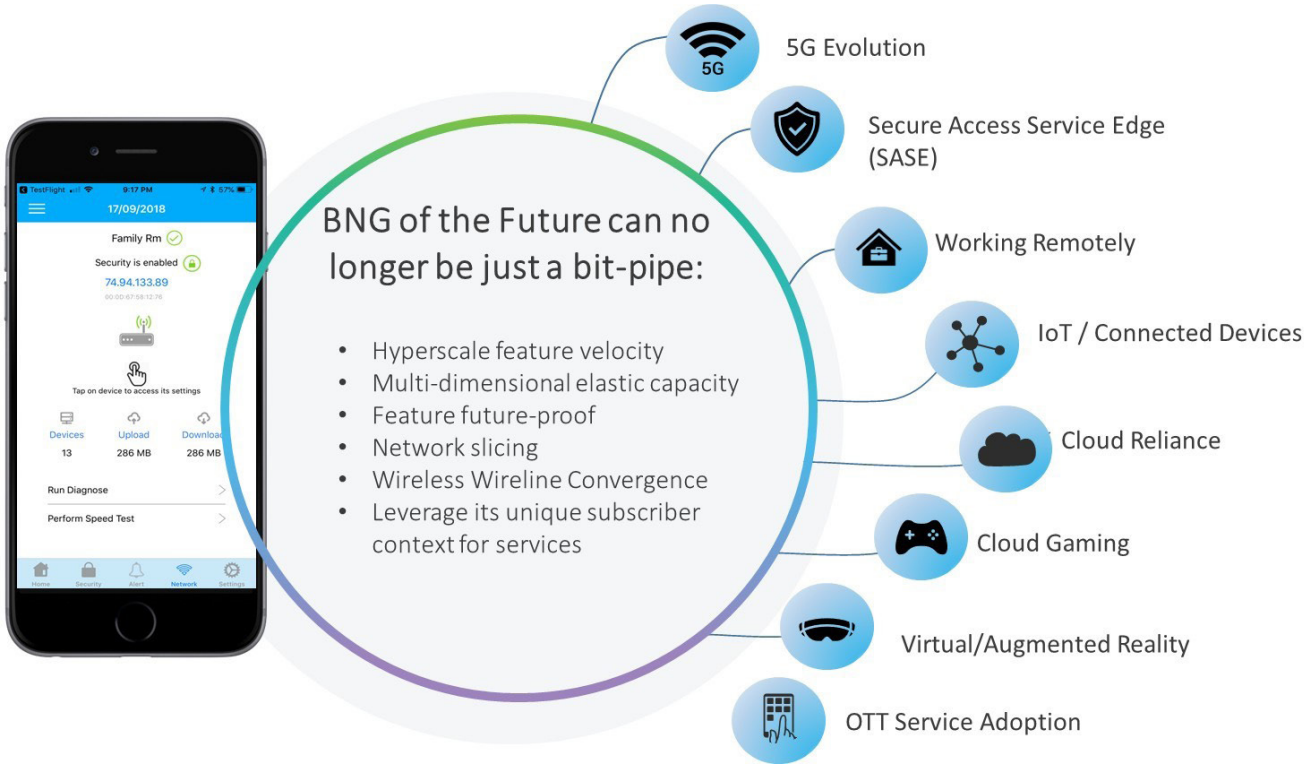

FIGURE 1: *Key Market Trends Driving BNG Requirements*

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Role of a BNG and the Drive for Cloud-Native

The fixed broadband network has many critical components, but the linchpin of it all is the Broadband Network Gateway (BNG). A BNG establishes and manages subscriber sessions by acting as the authentication point through which subscribers can connect to a carrier's broadband network. The BNG aggregates subscriber traffic from the access network and routes it to the carrier's core network and the Internet. All traffic in-bound from the Internet passes through the BNG on its way back to the subscriber.

More recently, user services have evolved to include streaming video (consuming up to 80% of the bandwidth), Voice over IP, gaming, work-from-home, virtual and augmented reality, and a multitude of other applications. This has not only increased the volume of transmitted information, but the traffic model has become very mixed with varying protocols and performance requirements.

These changes are driving many service providers to decide which path to take for their next-generation BNG. Should the industry move away from a proprietary hardware-based approach to a new open, cloud-native software-based approach using commercial off-the-shelf (COTS) hardware? Will it give them the agility, flexibility, reliability, and scalability offered by cloud-native deployments inside the cloud hyperscalers like AWS, Azure, and Google Cloud? The answer is yes. With a cloud-native BNG architecture, carriers can start to achieve improved economics and deliver new services at the speed enjoyed by the hyperscalers.

Benu vBNG Highlights

Agility & Flexibility

- Open APIs for 3rd party network functions and services
- Add new advanced features without constraints of proprietary ASIC limitations
- Geographically deploy user planes where needed
- Create user plane "slices" for specific use cases like enterprise, WWC or low latency applications

Elastic Scaling – In and Out

- No specialized hardware - runs on commodity COTS x86 hardware
- Dynamically apply CPU resources where needed and elastically scale up or down control planes and user planes which can also be upgraded and scaled independently
- Easily launch new user planes

Performance and Resiliency

- Architected to runs on virtual machines, bare metal or in containers
- 400+ Gbps per server, latency < 10 µs, jitter – 200 ns
- Independent failover resiliency for control and user planes
- 1:1 control plane and N:1 user plane high-availability

Operations Efficiency and Opex Savings

- Centralized control plane simplifies subscriber management, IP address allocation, and NBI integrations to OSS/BSS
- Distributed user planes deployed with just a few commands
- Leverage SDN if desired

Significant CAPEX savings

- Pay as you grow model – no big upfront chassis / system cost
- Utilize simple, low-cost, commodity aggregation switches
- Leverage diverse supply chain of COTS-hardware

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Hardware-based BNGs are limited to what the hardware supports and many of the monolithic platforms make it very difficult to introduce innovation into the network from other vendors. This is primarily caused by:

- Lack of an open hardware model leading to an inability to run third party software, slowing both innovation and introduction of new revenue-generating services.
- Lack of an open software architecture which stunts feature flexibility.
- Hardware-based deployment models come in a limited number of configurations and capacities. The decision to centralize or distribute the equipment becomes a long-term choice not easily changed.

These factors are too constraining in today's hyper-competitive market which demands agility, flexibility, performance, and a changed economic model.

Benu Network's Cloud-Native, Virtualized BNG

The solution begins with Benu's technology leadership in vBNG. Historically vBNG performance was too low to be economically viable, but now a vBNG hardware cost is lower than a BNG running on proprietary hardware.

The disaggregation or separation of hardware and software running in a virtualized environment delivers many benefits:

- It frees service providers from being locked-in to single-vendor hardware.
- Benu's solution runs on commercial-off-the-shelf (COTS) server hardware (x86- based) which provides better flexibility with the ability to match system sizing to bandwidth and session requirements driven by subscriber service needs.
- The separation of software speeds innovation by allowing third party applications to be introduced without the limitations of the ASIC or hardware.
- Provides diversity in the hardware supply chain, more competitive pricing, and better risk management in the event of a supply chain disruption.

Secondly, Benu was first to support the Broadband Forum and 3GPP standard for separation of the control plane from the user plane (TR-459 "CUPS" architecture, Figure 2). It too has numerous benefits:

- The user plane (or multiple user planes) can be geographically distributed and sized as required with elastic scaling (up or down) driven by bandwidth needs over time. This flexibility results in better efficiency and cost effectiveness.
- User planes can be deployed with different "slices" for specific use cases like Wireless Wireline Convergence (WWC), or support for low-latency Multi-Access Edge Computing (MEC) services, IoT, cloud-gaming, or streaming video.

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Virtual Broadband Network Gateway (vBNG)

- A centralized control plane simplifies subscriber management, management of IP address pools, and eases the implementation of northbound integrations to OSS/BSS systems.
- The control plane and user plane not only scale independently but are independently resilient.

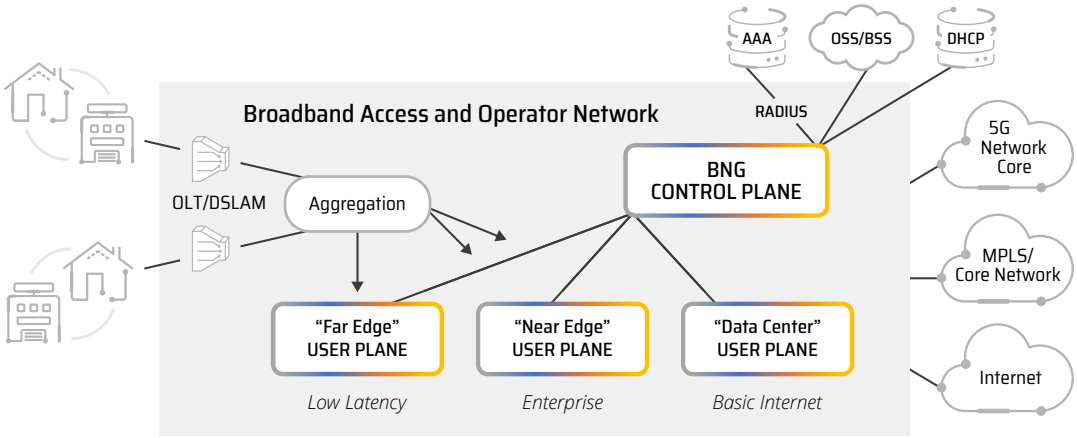

FIGURE 2: *Benu Disaggregated Virtualized BNG (CUPS Architecture)*

Benu Networks vBNG is part of Benu's SD-Edge family of solutions. The SD-Edge platform can be software defined to take on the personality of a vBNG, WiFi Access Gateway (WAG), CGNAT Gateway, or in the future, a 5G Access Gateway Function (5G AGF). This architecture provides tremendous value to a service provider.

Multiple Runtime Options

Benu Networks understands that service providers may differ in the way they choose to deploy our platform. Therefore, we have multiple runtime options to meet the needs of any carrier.

There are four (4) options for running our virtualized BNG:

- Bare Metal Network Appliance
- Virtual Machines (VM)
- Cloud-Native (Kubernetes and containers)
- Cloud (AWS EKS in Regions and Outposts)

Deployment Option #1: Bare Metal with the software running on a server without virtualization. This behaves much like a network switch or appliance and is a good solution for fixed carriers that are not yet ready to support a virtualized or cloud-native environment like the mobile operators.

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Virtual Broadband Network Gateway (vBNG)

Deployment Option #2: Running on Virtual Machines. Benu is qualified on KVM (Kernel-based Virtual Machine), VMware, and OpenStack virtualized environments. We partner closely with both VMware and Red Hat and can drop into existing virtualized environments including those used for mobile cores.

Deployment Option #3: Running in containers in a cloud-native Kubernetes environment. Benu is qualified on CNCF-based Kubernetes, Red Hat OpenShift, and VMware Telco Cloud Platform (TCP). Most of the 5G mobile cores are running cloud-native, and our software can easily drop into these environments so that operations teams can leverage the same operational framework across fixed and mobile subscribers.

Deployment Option #4: Running in cloud environments (public or private) including Amazon Web Services (AWS) using their Elastic Kubernetes Service (EKS) in AWS Regions and Outposts. Other cloud providers can also be supported.

Additionally, the software can be deployed with control and user plane separation (CUPS) or can be fully integrated into the same instance and hardware for a more monolithic approach. Regardless of how you initially choose to deploy, we can support you in migrating to a different mode later.

Benu Networks Delivers Value

Carriers gain tremendous benefit when deploying Benu Networks' cloud-native, disaggregated virtual BNG. By separating the control plane from the user plane (CUPS) and running on COTS hardware, a service provider can address the many challenges of operating in today's hyper-competitive environment.

Network costs decrease while flexibility increases. Multiple user planes can be deployed where they can be most geographically and functionally efficient. No longer constrained to vendor-specific hardware, the carrier can scale up or scale down as needed, add new services quickly, and employ an architecture built for wireline/wireless convergence.

In addition, when they choose Benu Networks' vBNG, built on our SD-Edge platform, they get the benefit of other functions such as WAG, CGNAT, services like malware/phishing protection, and in the future, 5G AGF. This combination of value and future-proof protection is why Benu Networks is leading the charge for transformation at the edge of the network.

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Supported Features

Access

- IPoE
- PPPoE
- QinQ (1:1, N:1 VLAN modes)
- MPLS pseudowire
- VLANs
- EoGRE
- L2TPv2/v3

Authentication and Accounting

- DHCPv4/v6
- DHCP relay
- IPv6 SLAAC
- Static IP
- DNS
- RADIUS
- VSA support in RADIUS access-accept
- Diameter
- HTTP redirect
- Walled garden
- Access loop identification
- Rest APIs
- Usage-based billing
- AAA load-balancing
- Multi-AAA accounting
- Analytics and flow logging: Syslog, SORMv3

Security and Protection

- Malware/phishing
- Parental control
- DoS protection
- Control plane protection
- Access control lists (ACLs)
- User and session security

Routing

- Dual stack IPv4/v6 BGP, OSPF, ISIS, RIP
- Route redistribution
- FIB/RIB scaling
- Static routing
- OSPF v2/v3
- OSPF, ISIS, BGP graceful restart
- BFD – IPv4, IPv6
- LDP
- MPLS
- ECMP
- Policy-based routing

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Supported Features

Traffic Management and QoS

- ACL
- Advance DNS ACL
- Per subscriber QoS
- Hierarchical QoS (H-QoS)
- 802.1p, DSCP, IP TOS, MPLS EXP
- QoS marking
  - Dual rate policer
  - Egress scheduling: assured and expedited forwarding (SP, CBWFQ, WRR)
  - Traffic shaping
- WRED congestion control
- IPv4/v6 fragmentation
- Application based policies

Provider Edge Services

- MPLS Layer 3 VPNs
- Virtual routing and forwarding (VRF)
- MPLS pseudowires
- L2 access to MPLS L3 VPN
- Configurable MTU size and MTU discovery
- Jumboframes

Multicast

- IGMP
- Multicast Listener Discovery (MLD)
- PIM – sparse mode (SM)
- Multicast scalability
- Multicast replication per subscriber and PPPoE

Reliability and Redundancy

- In-service software upgrades (ISSU)
- CP and UP individually statefully redundant
- vBNG UPs 1:1 or N:1 redundancy
- vBNG CP 1:1 redundancy
- Bi-directional forwarding detection (BFD)
- PW redundancy
- Failed process isolation and restart without impact
- Link aggregation (LAG) and LACP

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Supported Features

Management

- CLI interface
- Web-based GUI
- Remote Access – telnet or SSHv2
- RADIUS or TACACS+ authentication
- 15-Levels of admin authorization
- Custom-defined admin levels
- Multiple alarm handling and logging
- Remote Mgmt over IP protocols
- SNMP v1/v2c/v3
- IETF-Compliant MIBs for UP and CP
- SNMP traps
- Syslog
- NTP
- IPv6 MIB support
- Multiple alarms with logging
- Extensive set of packet counters
- All IPv4, IPv6 management features
- Flow logging and telemetry: Syslog, SORMv3
- Alarms and events: SNMP, JSON/HTTP
- Telemetry and analytics
- Configuration: Netconf/Yang
- Deployment and Orchestration: Kubernetes, 3rd-party VNFMs & VIMs
- In-band and out-of-band management
- Subscriber traffic mirroring
- PFCP for CUPS

Lawful Intercept

- RADIUS based intercept triggers
- Data security and encryption
- X1, X2, X3 interfaces

Other Network Functions & Mobile Integration

- CGNAT
- L2TP Access Concentrator (LAC)
- L2TP Network Server (LNS)
- Stateful Packet Inspection
- WAG
- Guest WiFi
- S2a
- Gx/Gy interface support
- Inline Service Stitching (SFC/NSH)

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Supported Features

Deployment Options

- Bare metal server
- Virtualized Machines
  - KVM
  - VMware
  - OpenStack
- Containerized (Cloud-Native)
  - CNF-based Kubernetes
  - VMware Telco Cloud Platform (TCP)
  - Red Hat OpenShift
- Private and Public Cloud