WHITE PAPER

Communications Service Providers
TCO Analysis

Total Cost of Ownership Analysis for a Wireless Access Gateway

An analysis of the total cost of ownership of a wireless access gateway running on merchant silicon hardware vs. industry-standard, high volume servers.

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Overview

This paper presents a high-level comparison of the total cost of ownership of running the Benu Networks' Operating System (BenuOS)* on an Intel® architecture–based platform vs. utilizing merchant-silicon built with 64-bit MIPS* NPU* processors. Each platform is configured to run the BenuOS wireless access gateway (WAG) network function. The WAG is utilized to provide large-scale Wi-Fi device aggregation via GRE tunnels, mobility, IP policy enforcement, and service edge routing in a carrier Wi-Fi network. This analysis will look into various factors that contribute to the cost of ownership in capital expenditure (CAPEX) and operational expenditure (OPEX) categories between the MIPS hardware and Intel architecture–based platforms.

Operating Principles

For the TCO analysis, the platforms were configured to function as a wireless access gateway (WAG) in a service provider's network. The goal was to push as much data throughput as possible through each platform and measure packet performance, latency, and jitter.

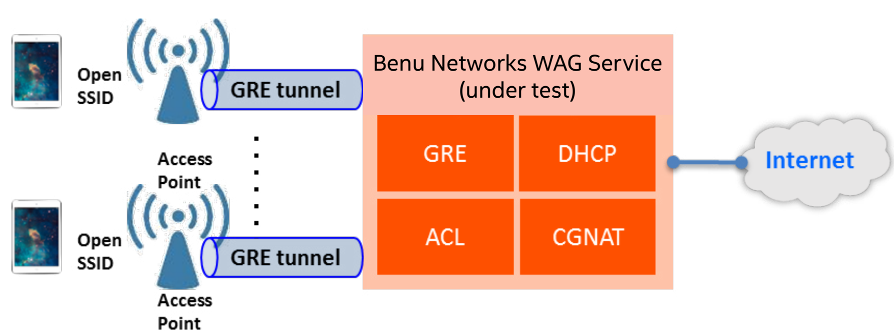

Exhibit 1. WAG service[1]

In a service provider's network, shown in Exhibit 1, the WAG network function aggregates access traffic from user devices via Wi-Fi access points (APs) that bridge all user traffic associated to the Wi-Fi SSID (open or secure) over a GRE tunnel that terminates on the WAG. The WAG is the first IP hop for all devices and provides all IP subscriber management and policy enforcement on each device. On the network side, the WAG connects subscriber traffic to the service provider's Internet core via L3 protocols. Wi-Fi APs are configured with Open SSIDs and bridge all user packets over a GRE tunnel to the WAG. The WAG applies different policies to each device, or on a per-SSID level. The WAG supports a number of inline IP services in fast-path that can eliminate the need for external appliances for features such as DHCP, CGNAT, ACL, and service edge routing (Static Route, OSPF, BGP, IS-IS) for both IPv4 and IPv6.

Exhibit 2 shows the upstream and downstream packet processing pipeline flow for our testbed.

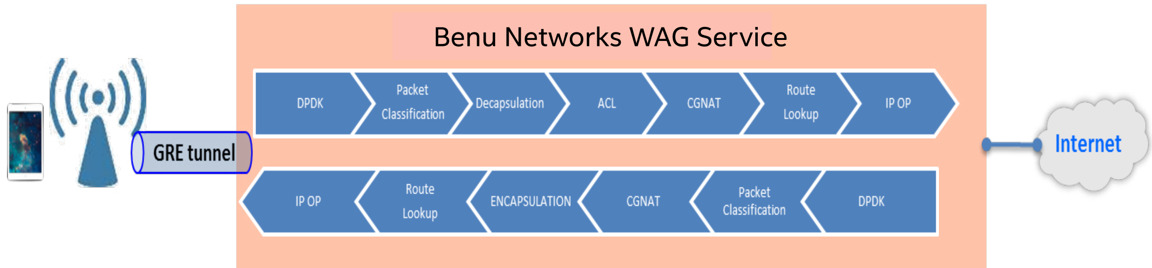

Exhibit 2. Upstream (above) and downstream (below) packet flow

In the upstream flow shown in Exhibit 2, the Intel architecture–based platform running the WAG service first receives packets from the DPDK layer; it then does packet classification to determine how the packet will be treated. In this case, the packet is a GRE tunnel and thus needs to be de-encapsulated. Inside the GRE tunnel are Ethernet frames from the UE device. The WAG then applies any ACL policies followed by CGNAT. Finally, the WAG does the route lookup to forward the packet to its immediate destination and sends it to the network side via IP OP operation.

In the downstream flow, the above-mentioned operations happen as shown in Exhibit 2. In the platform based on MIPS architecture, the upstream and downstream flows are similar with the exception that the DPDK layer is not available.

Subscriber traffic is simulated using industry standard traffic generators in a lab environment. Performance was measured in Gbps/PPS based on how much data throughput was delivered by each platform.

The WAG is configured with four interfaces utilizing 4 x 10G ports, an integrated DHCP server, and a CGNAT profile. Exactly 1024 subscribers are registered over 512 GRE tunnels sending to and receiving traffic from four network nodes

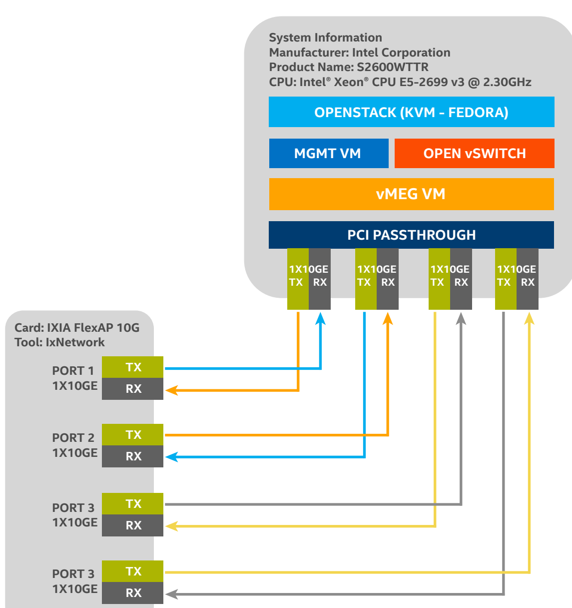

Exhibit 3. Intel architecture–based WAG test setup used for performance analysis

using the iXNetwork* tool. The operations considered for this test are de-encapsulation and encapsulation.

Performance Measurement Baseline

The same traffic model was run on both platforms and performance was measured. Since the two platforms use different architectures, they offer relatively different performance under the same traffic conditions.

Exhibits 4 and 5 show a comparison of the performance of the two platforms in handling bi-directional data traffic. At an IMIX packet size of 475 bytes, the platform based on MIPS architecture provided up to 39% higher performance in terms of throughput than the Intel platform.[2] At a higher packet size, the performance offered by the two platforms is similar in terms of throughput and packets per second processing. This was expected since the platform based on MIPS architecture is purpose built to run the WAG application.

The Intel platform has a lower latency than the platform based on MIPS architecture as shown in Exhibit 6, where the jitter is higher than the platform based on MIPS architecture as shown in Exhibit 7. At larger packet sizes, the performance between the Intel platform and platform based on MIPS architecture is comparable. The Intel architecture-based platform has the advantage of being an industry-standard, high volume server that can be used to run WAG or any other application that a service provider chooses without being locked into using the platform only for a WAG application.

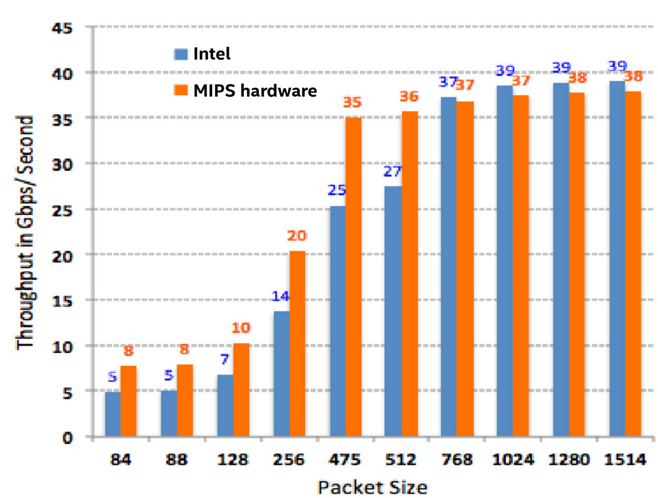

Exhibit 4. Bi-directional traffic throughput vs. packet size[2]

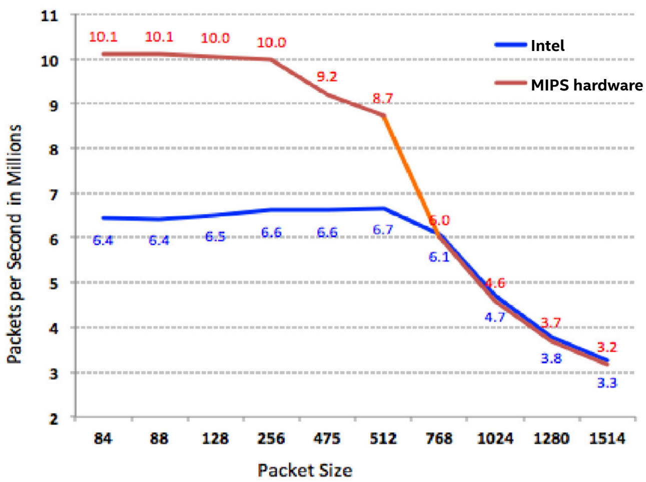

Exhibit 5. Bi-Directional traffic packets per second processed (in millions) vs. packet size[2]

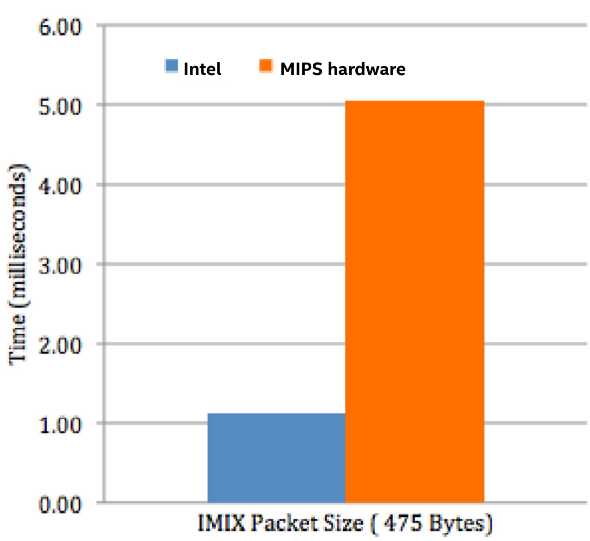

Exhibit 6. Latency at IMIX packet size 475[2]

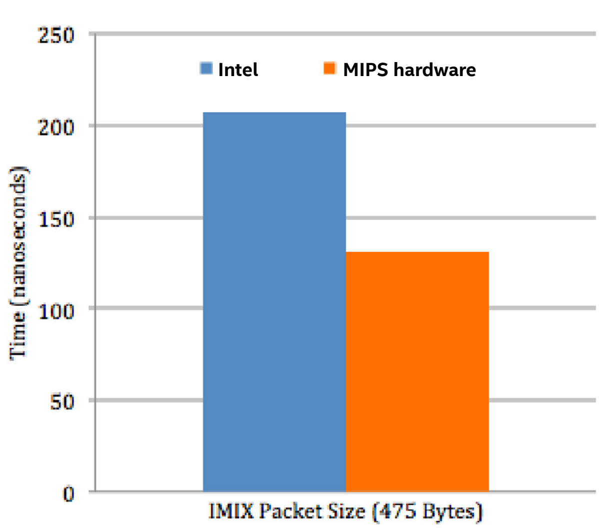

Exhibit 7. Jitter at IMIX packet size 475[2]

TCO Calculations, Results, and Conclusion

Exhibit 8 shows the TCO comparison for CAPEX and OPEX. Since both platforms will run Benu Networks software, hardware will primarily be considered for comparison. The overall advantage goes to an Intel architecture–based platform when compared to a merchant silicon solution. Using a one year comparison of CAPEX plus OPEX, the Intel architecture–based platform is 75% lower than that of a platform based on MIPS architecture.

COSTS	MERCHANT SILICON BASED SOLUTION	INTEL
CAPEX		
Hardware Unit (ASP)	$75,000	$15,000
Number of Units	1	1
CAPEX Sub Total	$75,000	$15,000
OPEX		
Power †	$797	$1,253
Cooling †	$797	$1,253
Real Estate †	$1,572	$1,572
Maintenance	$9,000	$1,800
CGL Subscription		$1,000
OPEX Sub Total	$12,166	$6,878
Total CAPEX + OPEX	**$87,166**	**$21,878**
Percentage savings		**75%**
PLATFORM SPECIFICATION		
System Throughput	50 Gbps (40 Gb used)	40 Gbps
Hardware Specification		
I/O Interface	5 x 10 GE ports	4 x 10 GE ports
Operating System	BenuOS	CGL
Rack Units (RU)	2	2
Height (inches)	3.5	3.5
Width (inches)	16.9	16.9
Depth (inches)	26.23	27.95
Weight (lbs.)	45	40
Input Voltage (V)	100 to 240	100 to 240
Max Power (W)	700	1100
Maintenance	12%	12%
† OPEX Variables	**Assumed Costs**	
Cost / kWh	$0.13	$0.13
Cost / RU	$786.00	$786.00

Exhibit 8. TCO Calculations for platform based on MIPS architecture and Intel architecture–based platform using DPDK

Comparing CAPEX, the average sale price for the merchant silicon based solution is approximately $75,000, and the industry-standard, high volume platform used in this benchmark retails for approximately $15,000. The reason the merchant silicon solution is more expensive is due to manufacturing complexity, more expensive components, overhead, and vendor markup of the hardware. The industry-standard, high volume server can be purchased by the customer and reused for many different applications, and volume-based discounts could reduce the price.

OPEX includes costs associated with running a network box in the operator's network facility, which are largely power, cooling, space, and maintenance expenses. In our TCO example, we provide cost items for power, cooling, real-estate, and maintenance on merchant silicon hardware. Power and cooling variable costs are based on kilowatt hour (kWh) charges. This example uses a cost of $0.13 per kWh, which is typical in major developed markets. Hardware maintenance costs vary between vendors, which extends the warranty of hardware. In this example, 12% of the average sale price was used to calculate the annual maintenance costs. The last item is the annual support license fee to run a carrier-grade Linux* (CGL) distribution, which only applies to the industry-standard, high volume server solution since a CGL is included in the merchant silicon solution. The real-estate costs are calculated on a per Rack Unit cost and are highly variable. In this example, $786 per RU and is the same for both platforms since they are the same 2 RU form factor.

While the overall performance for the Intel platform is comparable for the same form factor (2 RU, 4 x 10 GE ports),[2] the service provider is in a unique position to take advantage of Intel's rapid product cycle, where the next generations of Intel processors on industry-standard, high volume servers offer improved performance at better price points. Service providers can re-purpose the existing platform for other data center applications that use Intel architecture and replace it with newer and faster servers and still keep a lower TCO.

Test Details

Intel Hardware Platform

All tests in this report were generated with the following platform:

ATTRIBUTE	DETAIL
CPU	Intel® Xeon® CPU E5-2699 v3 @ 2.30GHz
Number of Cores on board	36
Cores Used for BenuOS*	32
BenuOS Used Core Specifications	26 Data path 6 Control path
Optimization	CPU Pinning, Dedicated CPUs, Grub-isolcpu's
Memory	64 G

http://ark.intel.com/products/88281/Intel-Server-Board-S2600WTTR

BenuOS* Software Components

The BenuOS, when running in the Appliance mode, consists of the following:

- OS (Fedora* 21)
- OpenStack* Kilo* with Open vSwitch* (non-accelerated) for the management interfaces
- 1 VM for management functionality (Management VM)
- 1 VM for control plane and data path (Application VM)

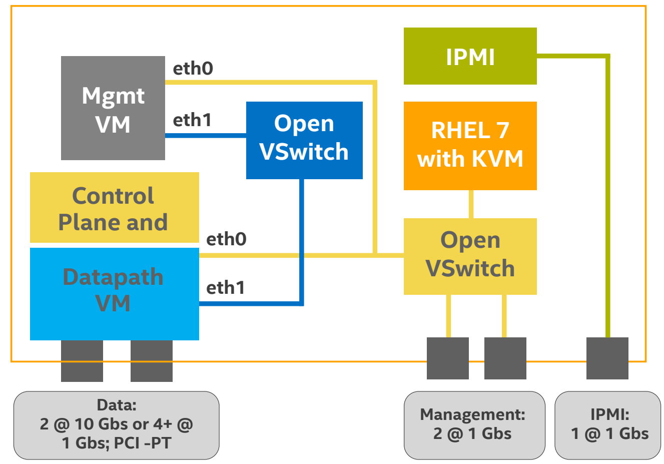

Exhibit 9. Dual core x86 COTS Server

Test Description

In this test, four 10G ports from the Ixia* Flex AP card are directly connected to the four 10G ports of the BenuOS.

For Unidirectional Tests

- Using the IxNetwork tool, four DHCP streams are constructed to register 256 subscribers over 128 tunnels with each stream. The total numbers of subscribers registered are 1024 over 512 tunnels.
- Four of the 10G interfaces from the IxNetwork tool are mapped to the streams constructed as the access interfaces sending upstream/downstream traffic from subscribers to network/network to subscribers.
- Each stream sends continuous traffic at a line rate for 256 subscribers over 128 tunnels with packet sizes varying from 84 bytes to 1514 bytes and with IMIX traffic.
- The aggregate of all the four streams mapped to four 10G interfaces/ports on the tool implies pushing 40G traffic into the box.

For Bi-Directional Tests

- Using the IxNetwork tool, four DHCP streams are constructed to register 256 subscribers over 128 tunnels with each stream. The total numbers of subscribers registered are 1024 over 512 tunnels.
- Two of the 10G interfaces from the IxNetwork tool are mapped to the streams constructed as the access interfaces sending upstream traffic from subscribers to the network.
- Two of the 10G interfaces from the IxNetwork tool are mapped to the streams constructed as the access interfaces sending downstream traffic from the network to subscribers simultaneously.

- Each stream constructed for upstream/downstream to achieve bi-directional sends continuous traffic at a line rate for 512 subscribers over 256 tunnels with packet sizes varying from 84 bytes to 1514 bytes and with IMIX traffic.
- The aggregate of all the four streams mapped to four 10G interfaces/ports on the tool implies pushing 40G traffic into the box.

Stats Collection

- The stats are collected with respect to each stream and port from the IxNetwork tool when each port is pushing traffic at 100% line to achieve the aggregate of 40G.
- The measurements are recorded once the steady state traffic flow is achieved, most likely between 2 and 3 minutes from the time the traffic flow has started.
- For the throughput, the Rx data rate achieved on each 10G port was aggregated and recorded.
- For the frame rate, the Rx frames per second is aggregated and recorded.
- For the latency, the aggregated average of the Rx store-and-forward latency was recorded for average, maximum, and minimum values.
- For the jitter, the aggregated average of the Rx store-and-forward latency was recorded for average, maximum, and minimum values.
- The statistics collected from the IxNetwork tool include:
  - Rx frames transmitted per second from subscribers to the network.
  - Rx data rate in MBPS from subscribers to the network in frames per second.
  - Store-and-forward average/maximum/minimum latency from subscribers to the network in nanoseconds.
  - Average/maximum/minimum delay variation from subscribers to the network in nanoseconds.

Abbreviations

ACL	Access Control List
APs	Access Points
BGP	Border Gateway Protocol
CGNAT	Carrier Grade Network Address Translation
DHCP	Dynamic Host Configuration Protocol
DPDK	Data Plane Development Kit
GRE	Generic Routing Encapsulation
IMIX	Internet Mix
IS-IS	Intermediate System to Intermediate System
OSPF	Open Shortest Path First
PPS	Packets Per Second
SSID	Service Set Identifier
UE	User Equipment
WAG	Wireless Access Gateway

[1] Figures courtesy of Benu Networks.

[2] Test performed by Benu Networks. Configurations: see Exhibit 8 for details on the merchant-silicon based solution. See the "Test Details" section for hardware configurations of the Intel architecture-based solution and other material testing conditions.