



Economic Advantages of Virtualized WiFi Access for VoWiFi

Sponsored by Affirmed Networks

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EXECUTIVE SUMMARY

While voice revenue has remained largely flat in recent years, delivering ubiquitous, high-quality voice services remains a mandate for every mobile operator. The challenge for mobile service providers is this: How to reduce the cost of delivering voice services while increasing coverage. The solution, in large part, will come from the ability to leverage existing Wi-Fi coverage through Voice over Wi-Fi (VoWiFi) technology.



According to ACG Research, the implementation of VoWiFi across the mobile network can save mobile operators 1¢/min/subscriber on voice calls.

VoWiFi requires integration with a mobile operator's core network; an evolved packet core (EPC). The type of VoWiFi solution you choose to deployment can have a significant impact on the success of the



Using an Network Functions Virtualization (NFV) based VoWiFi solution can, for example, reduce the total cost of VoWiFi implementation by 45% while accelerating service deployment time by 3x.

VoWiFi implementation.

Combining VoWiFi and NFV has a compound, positive effect:

- » It expands network coverage and capacity far more cost effectively than other wireless access technologies such as RANs and added wireless spectrum;
- » It allows mobile operators to accelerate the deployment of VoWiFi services through virtualization and automation, leading to a more agile and scalable business model.

In this research, ACG Research examines the market drivers, challenges and paths to VoWiFi, including a five-year total cost of ownership (TCO) analysis that compares present mode of operation (PMO) using purpose-built appliances versus the virtualized mode of operation (VMO) currently offered by leading vendors such as Affirmed Networks.

THE MARKET CHALLENGE

The current forecasts and studies in the mobile networking industry point to a tremendous rise in mobile data traffic volume¹. Wi-Fi access is considered the technology of choice to alleviate the pressures in broadband radio access networks (RANs). The importance of deploying Wi-Fi as a complementary access technology to RANs stems from the need for increased capacity while optimizing network infrastructure costs to meet specific business KPIs such as lower subscriber churn and lower operational expenditure. Operators' infrastructure objectives are:

- » Reducing opex and capex costs in their network
- » Improving customer satisfaction and reducing churn through better and more ubiquitous coverage

This last objective is key, as churn rates for North America mobile operators in 4Q 2016 were between 1.31% (Verizon) to 2.39% (T-Mobile USA).² When one considers that the cost of acquiring a new customer is about \$250; the importance of churn becomes apparent. For every 1% churn rate, a mobile operator with one million subscribers, for example, can expect to spend \$2.25 million per year because of customer churn.

THE WI-FI OPPORTUNITY

It is estimated that 80% of all voice calls are made within range of a Wi-Fi network. Voice over Wi-Fi (VoWiFi) enables mobile service providers to securely connect their core networks with trusted and non-trusted W-Fi networks in order to provide seamless voice services between Wi-Fi and 3G/4G/LTE networks. Although it is true that voice calls comprise a fraction of data relative to video and other nonvoice data, it is still an important metric for mobile subscribers, who expect clear and non-disruptive voice services regardless of the underlying network technology. The benefits of VoWiFi extend to both subscribers and mobile operators:

For subscribers, VoWiFi offers:

- » Improved indoor wireless coverage
- » Better call quality/security over Wi-Fi
- » Service continuity and seamless handover as subscribers roam or move indoors/outdoors

For operators, VoWiFi offers:

- » A cost-effective way to offload RAN traffic
- » Increased capacity/coverage without investing in expensive RAN buildouts or additional wireless spectrum
- » Higher customer satisfaction/loyalty
- » New revenue generation opportunities through additional Wi-Fi services (see Table 1)

TABLE 1

| SERVICE | BENEFITS TO SUBSCRIBERS | BENEFITS TO OPERATORS |
|--------------------------------|--|---|
| Inbound/Outbound Roaming | Use one number (one SIM) Internationally | Roaming agreements to increase revenue; competitive services to subscribers |
| Increase Market Share | May see lowering prices or additional price options | Increase in marginal revenues; Subscriber service segmentation |
| Hosted Wholesale to MVNOs | Ubiquity of service availability; Increase options in selection of service providers | Increase in revenue streams via strategic alliances with MSOs or MVNOs (can offer premium services through packet core) |
| Location-based Services | Increased access to goods and services | Avoid bandwidth and service commoditization by offering personalized services |
| Replace Landline in Households | Reduce cost of communication | Increase service portfolio |
| Increase Number of Calls | Lower cost per call made | Increase network efficiencies; Increase marginal revenue |

¹ <https://www.statista.com/statistics/271405/global-mobile-data-traffic-forecast/>

² <https://www.statista.com/statistics/283511/average-monthly-churn-rate-top-wireless-carriers-us/>



TRUSTED WI-FI ACCESS GATEWAY (TWAG)

The role of the Trusted Wi-Fi Access Gateway (TWAG) is to bring Wi-Fi communications into the mobile network experience seamlessly. The TWAG supports smooth handoff between cellular and Wi-Fi sessions as well as consistent enforcement of policies, authentication/identification, charging, etc. Since the TWAG is a gateway for trusted Wi-Fi endpoints, data that passes through the TWAG does not need to be encrypted.



EVOLVED PACKET DATA GATEWAY (EPDG)

What happens if the Wi-Fi network is not trusted? In this case, MNOs would need to deploy an evolved Packet Data Gateway (ePDG) to provide the necessary IPsec encryption in addition to the other gateway functions (session handoff, policy enforcement, AAA services, etc.). This is not a trivial task; in fact, IPsec encryption represents a very real chokepoint in the carrier network as carriers may now have millions of additional IPsec processes to perform at the gateway. WiFi calling is a main driver for ePDG deployments.

WHY WI-FI NOW?

ACG Research has closely monitored the VoWiFi market for years. In 2015, we noted that VoWiFi had moved from an opportunistic feature for mobile operators to a requirement. The market has seen a tremendous growth in acceptance of Wi-Fi calling and support among Tier-1 and Tier-2 global operators including AT&T, T-Mobile, Sprint, Verizon, Vodafone, Telefonica O2 and Three.

The appeal of VoWiFi lies in its economics. Although the choice of technology plays a key role in determining total cost of ownership (TCO) and time to market (TTM), as we'll see, the foundational value of VoWiFi stems from the increases in calling capacity and revenue streams. This has led to the so-called "Wi-Fi First" trend where a smartphone connects to Wi-Fi when available, particularly when the subscriber is indoors, and then attaches to the macro (LTE) network second. By doing so, the "Wi-Fi First" saves the mobile network operator valuable radio resources, while also improving the user experience.

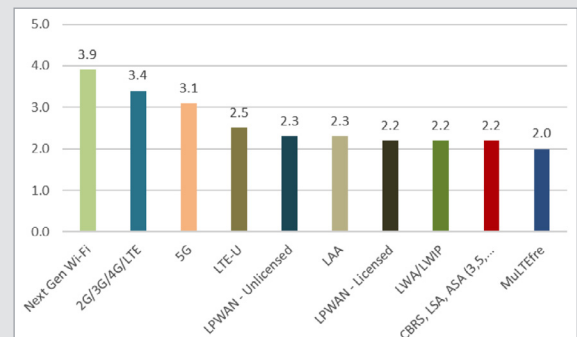
There are two major areas to consider:

- » Total Cost of Ownership (TCO) savings
- » Comparison of Earning Before Income Taxes, Depreciation and Amortization (EBITDA)

The Wireless Broadband Alliance(WBA)³ concluded the following:

- » By 2020, nearly 80% of the surveyed operators (respondents) will be deploying Next Gen Wi-Fi
- » In future network strategies, Next Gen Wi-Fi remains very important, exceeding traditional and emerging wireless technologies

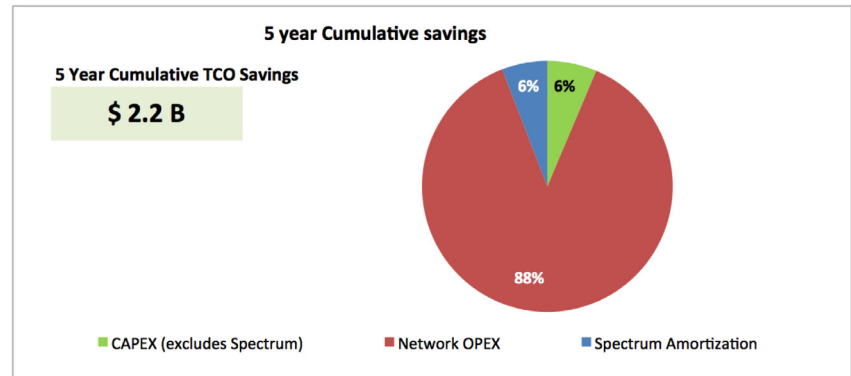
FIGURE 1 - IMPORTANCE OF WIRELESS TECHNOLOGIES IN NETWORK STRATEGIES BY 2020



³WBA Industry Survey 2016, December 2016 www.wballiance.com/resources/industry/reports

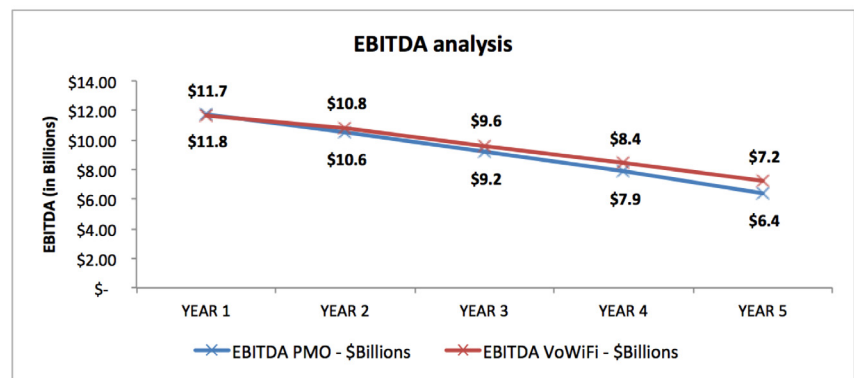
Our examination of the economies of VoWiFi for one mobile operator has shown \$2.2 billion in TCO savings based on an average starting point of 6% subscriber penetration and rising to 26% when deploying untrusted Wi-Fi access points versus new RANs. By using VoWiFi in lieu of its current operating mode, the operator was able to save one cent per minute per on mobile voice calls, resulting in the \$2.2 billion savings, with opex taking the lion share of the total savings (at 88%).

FIGURE 2 - 5-YEAR CUMULATIVE SAVINGS



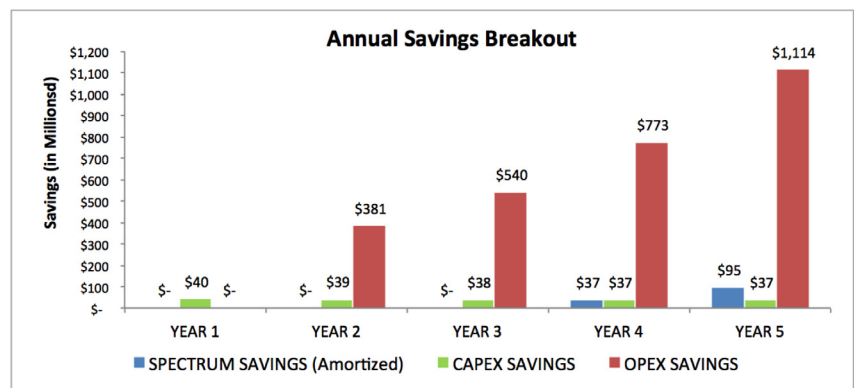
For the same scenario, a comparison of EBITDAs showed a cumulative increase of about \$2B for VoWiFi versus PMO (using RANs only for access) over a 5-year period.

FIGURE 3 - EBITDA ANALYSIS



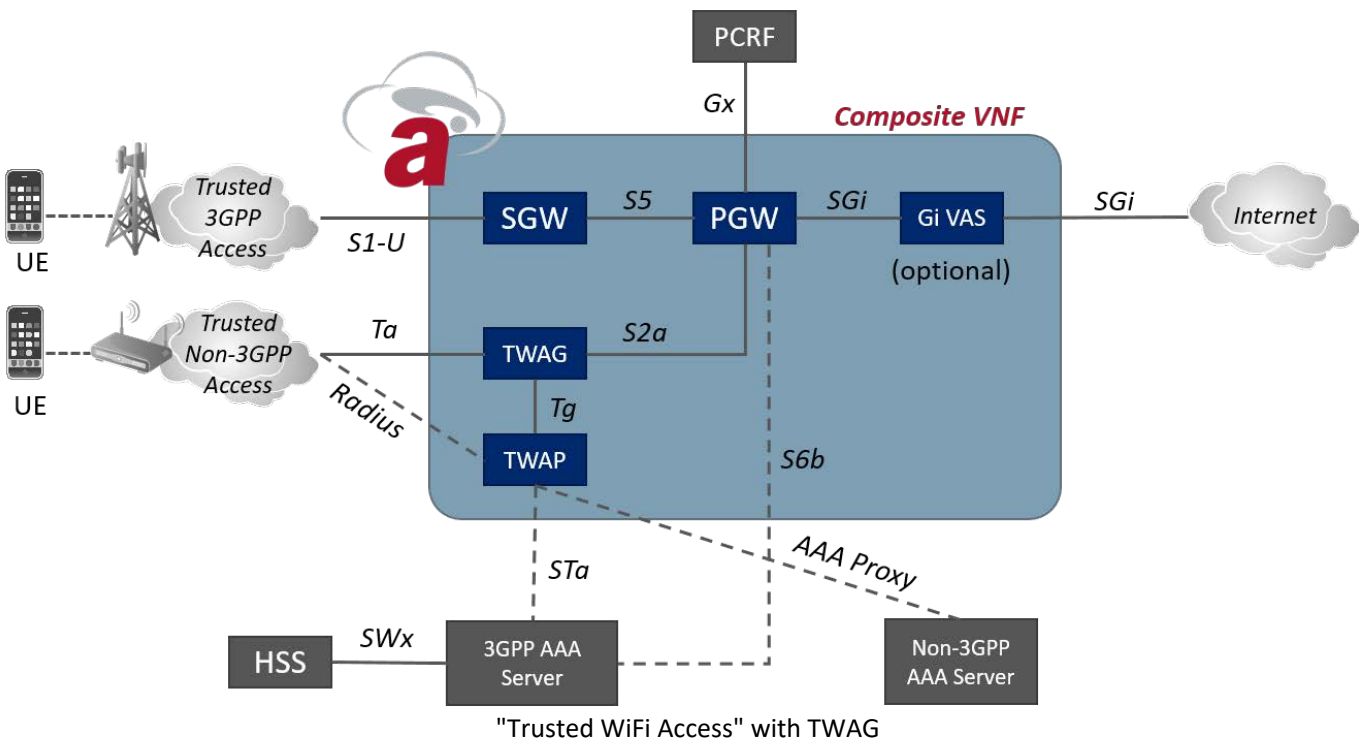
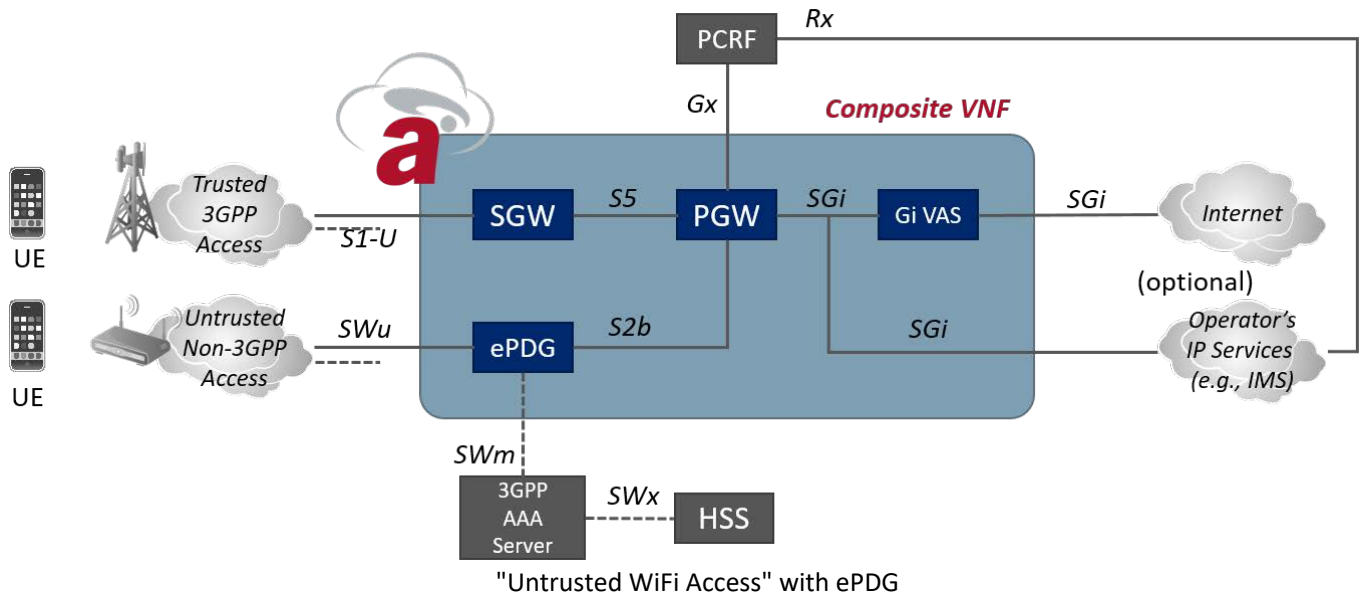
Opex is the major expense for mobile operators and the savings shown in the chart depict the impact from the use of unlicensed spectrum vs. licensed. Specifically, for ePDG, the major savings stem from WiFi access Point maintenance and Site Rental.

FIGURE 4 - DETAILED ANNUAL SAVINGS



CHOOSING THE RIGHT PATH TO VOWIFI

There are two different paths to VoWiFi integration, depending on the Wi-Fi access network itself. If the Wi-Fi access network is trusted (i.e., owned and managed by the mobile operator), then it is connected to the mobile operator's EPC via a Trusted Wi-Fi Access Gateway (TWAG) using an SaMOG (S2a Mobility based on GTP) tunnel. In the more likely scenario that the Wi-Fi access network is not managed by the mobile operator (i.e., "untrusted"), then the mobile operator would direct that traffic through an evolved Packet data gateway (ePDG) using IPsec tunnels. The figures below shows both examples.



A basic requirement for infrastructure deployment is to ensure that the introduction of any system or platform does not destabilize the network operation and offers reliable service to its subscribers. Therefore, it is important that the VoWiFi implementation adheres to this requirement and meets carrier-grade standards. Untrusted or public Wi-Fi access infrastructures are currently shifting to become carrier-grade, partly in anticipation of the demand that IoT (Internet of Things) applications will bring. (<http://telecoms.com/446911/most-operators-planning-carrier-grade-wifi-to-profit-from-iot-research/>.) Connectivity to the packet core through hotspots and home/business Wi-Fi access is generally more attractive to mobile operators because they do not have to deploy and manage these networks.

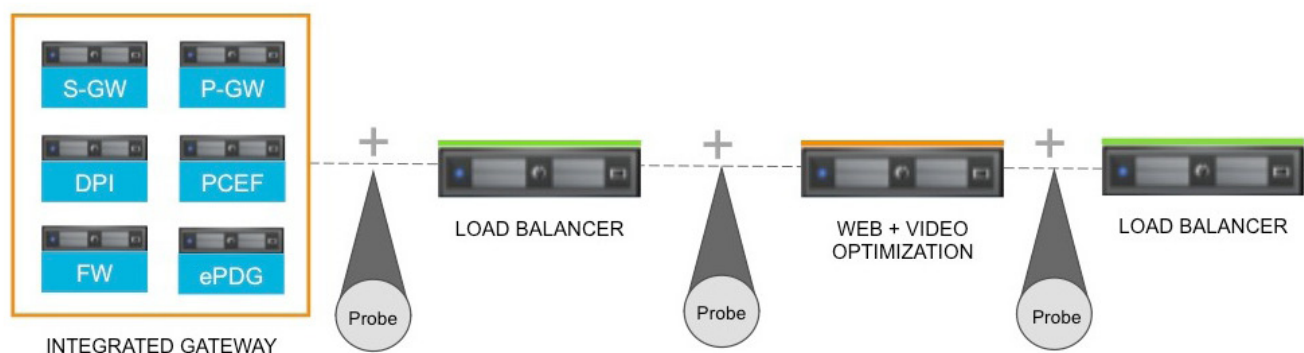
PMO VS. VMO: A TALE OF TWO IMPLEMENTATIONS

PURPOSE-BUILT APPLIANCES

Today, in their present mode of operation (PMO), mobile services providers would deploy TWAG or ePDG elements as purpose-built appliances. This approach, while familiar and reliable, presents several long-term challenges:

1. Because scaling is achieved by the insertion of new boards or, worse, new systems in the network, the PMO approach adds cost and complexity to the network.
2. Network updates require meticulous planning and integration, testing and verification processes that are labor intensive. Other planning considerations may include the advanced purchase and long-term storage of replacements parts for these elements.
3. If the operator's forecasts for subscriber demand are off by a few percentage points, there is the cost of over or under dimensioning the network, which further increases the cost levels or impacts revenue streams.

FIGURE 5 - PMO APPLIANCE BASED ARCHITECTURE WITH COMBINED EPDG AND GATEWAY FUNCTIONS

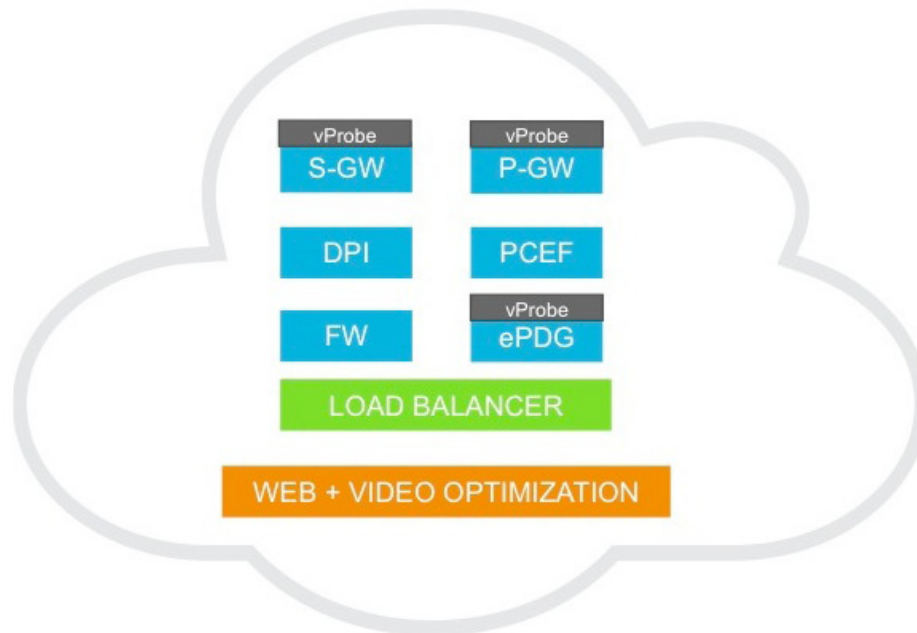


VIRTUALIZED WIFI

The advent of software-defined networking (SDN) and NFV initiatives has created a new model for network expansion, the virtualized method of operation (VMO). With their inherent elasticity, virtualized resources can be quickly and easily scaled up or down as needed. Integration, testing and verification with VMO can also be carried out much faster than with purpose-built infrastructure by using COTS-based servers and automated provisioning.

An NFV-based infrastructure offers service agility that enables the mobile operator to define, implement and deploy new services using automated provisioning and orchestration in a much faster timeframe. Services can be modified based on subscriber feedback or analytics to support the “fast fail” approach successfully used by over-the-top (OTT) app providers. This newfound service agility also addresses the subscriber’s high expectations of rapid response time to their requirements/ requests which, in turn, lowers churn.

FIGURE 6 - ADVANCED VIRTUALIZED ARCHITECTURE WITH COMBINED VIRTUALIZED EPDG, GATEWAY FUNCTIONS AND VIRTUAL PROBES



CONSIDERATIONS IN CHOOSING A VIRTUALIZED SOLUTION

The two expected benefits of NFV-based infrastructure are network elasticity (both in terms of assets and resources) and the opportunity to automate the different workflows, which historically have been carried out via a series of manually driven tasks. For a virtualized evolved Packet data Gateway (vePDG), the following considerations and capabilities will determine the ultimate effectiveness of the VoWiFi implementation:

- » **Automated Provisioning:** The vePDG should enable the mobile operator to easily and quickly run an application and modify its attributes dynamically. Examples of these attributes are bandwidth, number of subscribers/endpoints and storage requirements. This capability results in a judicious use of resources such as virtual machines (VMs).

- » **High IPsec Scaling:** The solution should support exceptional scalability of VMs when configured when configured for IPsec. For example, one million IPsec tunnels per VM, with elasticity of resources and automated provisioning of additional IPsec tunnels as needed.
- » **QoS:** The vePDG should enforce quality of service (QoS) guarantees on the packet core side as well as the untrusted Wi-Fi access point side. A policy control product (Gx interface) must be used to set policies for the subscriber for Wi-Fi services. Other options include the ability to offer QoS for tiered services, such as using dedicated bearers to support delay-sensitive applications and DSCP marking to set different QoS level on different interfaces of the transport network (e.g., IP layer).
- » **DPI:** The VoWiFi solution should support deep packet inspection (DPI), analytics, media optimization, security and policy enforcement. These functions will assist the operator to better manage the network, ensure a smooth-running operation and enable them to offer enhanced services.
- » **Packet Forwarding Architectures:** The vePDG should deliver high performance and optimal usage of virtual CPUs as well as the ability to use fast paths through the NFVI stack via methods such as SR-IOV.
- » **Virtual Probes:** The VoWiFi solution should provide network visibility and analytics to enable the operator to manage and mitigate network issues. The traditional modes of network visibility—such as SPAN ports to capture network traffic—do not work in virtualized environments as VMs move from one server to another. Affirmed Networks’ integrated Virtual Probe (co-located with each VNF, no separate Probe VNF required) is an excellent example of how visibility and analytics can be executed efficiently in a virtualized environment.

TABLE 2 - VePDG BASIC INPUT ASSUMPTIONS FOR TCO ANALYSIS

| SCENARIO ASSUMPTIONS: FIVE YEARS | |
|---|-----------------------------|
| Number of subscribers ePDG | 1,000,000 |
| Number of default bearers per ePDG subscriber | 1 |
| Number of dedicated bearers per ePDG subscriber | 0.25 |
| Average percentage of ePDG subs in active call | 7.5% |
| Average throughput during active call (KBPS) | 200 |
| Volte to VoWiFi handover | 2 |
| VoWiFi to Volte handover | 2 |
| Server | HPE C7000 with 1x10GE ports |

A FIVE YEAR TOTAL COST-OF-OWNERSHIP COMPARISON

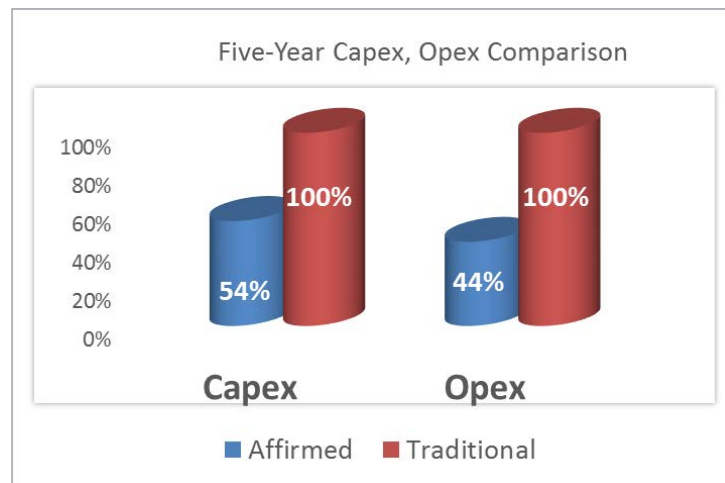
ACG Research conducted two separate economic analyses covering cost differentials between PMO and VMO implementations of the ePDG application. ACG analyzed the capital and operational expenditure, including relevant KPIs such as return on investment (ROI) and cumulative cash flow.

ACG Research conducted an analysis of Affirmed Networks vePDG versus a purpose-built competing system under a consumer scenario to assess their economic differences. The analysis was centered on the scaling and feature differentials of the two solutions, using publicly available data from both solutions. A realistic, typical call model was used based on a current market balance of 2G, 3G and 4G RATs and Wi-Fi access. Signaling traffic included Gx/Gy/Gz transactions in addition to inter RAT and

inter SGW handover. Attach and Detach events were also considered in the calculations. Other service such as DPI (Layers 3 and 4) plus Heuristic Analytics were also included in the analysis. Additional information on this analysis can be found in the white paper, [Choosing a Virtual Path to Carrier-Grade Wi-Fi Services](#).

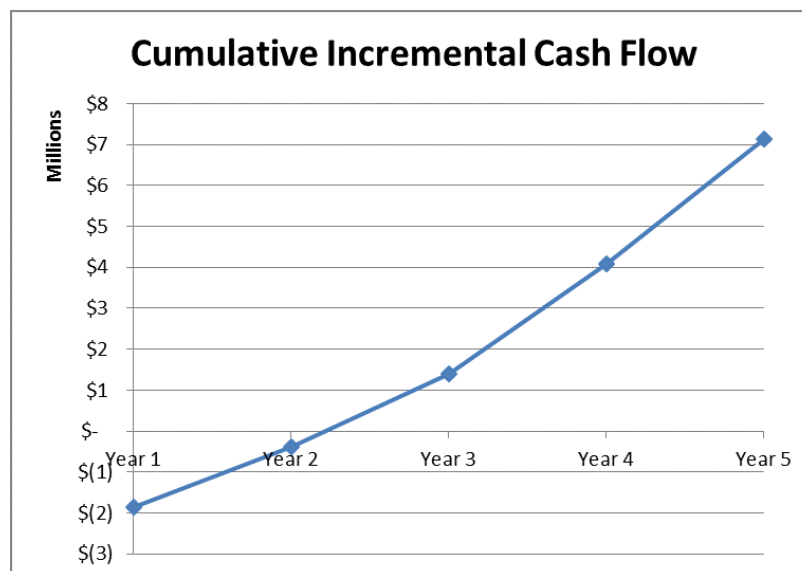
Figure 7 summarizes the variables that were assumed for analysis and quantification of the competing solutions over five years.

FIGURE 7 - FIVE-YEAR TCO COMPARISON



ACG found that the Affirmed vePDG presented a 52% lower TCO level and an ROI of 51% versus the traditional purpose-built system. The nominal values are given in Figure 4.

FIGURE 8 - FIVE-YEAR INCREMENTAL CASH FLOW FOR AFFIRMED NETWORKS VePDG



The economics clearly point to major advantages for the Affirmed solution.

CONCLUSION

Operators' high-level objectives are always to generate new revenue streams and, at the same time, contain the cost of their network assets and operations. For mobile operators, the connectivity and integration of Wi-Fi access into their packet core can meet both of these objectives. Operators have seen their greatest cost savings by reducing their deployment of RANs and offloading broadband cellular network data to Wi-Fi access networks.

Deployment of infrastructures based on virtualized packet core and Wi-Fi software stacks has given operators additional arsenals to reduce their cost of ownership, automate services of their networks and improve overall service agility. Although the TCO advantages of a virtualized infrastructure are compelling on their own, the added advantages that virtualization brings in terms of service automation, creation and agility deliver compelling long-term benefits that make it the clear choice for mobile operators that wish to maximize the benefits of a VoWiFi implementation.

ABOUT AFFIRMED NETWORKS

Affirmed provides a complete fully virtualized WIFI access solution for Mobile and Fixed service providers. Awarded as the "Best Next-Gen Wi-Fi Network Infrastructure" by the Wireless Broadband Alliance, offers a fully cloud native Wi-Fi solution featuring complete TWAG/TWAP and ePDG functions that can be deployed on commercial off-the-shelf (COTS) servers or within the vEPC on virtually managed hardware.

Affirmed's Wi-Fi gateway solution is designed to provide the most robust, reliable and flexible solution on the market today, featuring:

- » Ultra-high performance on commercial x86 servers and blades;
- » Open support for popular hypervisors from VMware, KVM and OpenStack;
- » Full compliance with ETSI NFV standards;
- » Easy integration with the Affirmed vEPC or third-party EPC solutions;
- » Fully virtualized IPsec tunnels for top security enabled by Intel® AES New Instructions and Intel® Multi-Buffer Crypto for IPsec Library technologies.
- » Embedded vProbe
- » 5G ready architecture;
- » Seamless delivery of core network services including policy/charging, packet inspection, value-added service/content optimization and workflow orchestration.

