The Business Value of an Integrated NFV Infrastructure

Executive Summary

Communication service providers (CSP) modus operandi (MO) for competing in today's dynamic market environment is to accelerate time-to-market for services demanded by their subscribers while minimizing the cost to do it. Deployment of an SDN/NFV-based infrastructure has been touted as a critical step for achieving these goals. CSPs have come to the cold realization that it is not a straight-forward task to (re)build and migrate from their current infrastructures to an SDN/NFV-based one. Major challenges faced by CSPs include the need for expensive (and mostly scarce) labor resources and finding ways to do the migration faster than their competitors. Another major challenge stems from the paradoxical goal of avoiding vendor lock-in, which in turn can increase complexity and overall costs – taking on the formidable task of integrating multiple best of breed discrete system components. Similarly, while pre-integrated NFV solutions hold the promise of reducing overall costs, CSPs run the risk of locking themselves into single-vendor implementations.

One approach to alleviate the above challenges is to find a proven, reliable business partner that offers solutions that are pre-integrated AND provide the flexibility to accommodate third party technologies.

HPE's pre-integrated system is one example of this approach. HPE offers top-to-bottom HPE solutions in addition to solutions that integrate third party tools. Furthermore, it has a proven track record with its professional services, Industry standards-based hardware, and a complete set of SDN/NFV-based software components – whether from its own portfolio or its partners, e.g., Helion carrier-grade OpenStack, VIMs, Open vSwitches, SDN Controller, and a host of partners that offers Virtualized Network Functions (VNFs) and VNF Managers (VNFMs) for specific services.

This paper describes ACG Research's economic analysis of two approaches for integrating and deploying of SDN/NFV solutions: 1. **Do-It-Yourself (DIY) integrated** - using best-of-breed, discrete components 2. **HPE Pre-integrated** – using HPE's NFV system, built using HPE's own, as well as its partners', products.

The analysis identifies labor and opportunity cost differences between the two approaches. ACG found that the difference in total labor costs between DIY and HPE's to be 61% lower for two targeted VNFs (vEPC and vIMS) in favor of HPE. The opex savings for life-cycle management were found to be close to 30% lower, again in favor of HPE. The opportunity cost of using discrete components was found to be over $653K for every 10,000 customers lost due to late market entry for the same service.

Introduction

The megatrend in networking, i.e., SDN/NFV has been touted as a panacea for all the current economic ills faced by CSPs. While the technical and economic advantages of network virtualization have been extensively articulated, the journey to a fully virtualized network infrastructure has proven to be difficult. Communication System Providers (CSP) have realized that migrating legacy infrastructures to virtualized implementations will be a very costly and risky task. As a result, many CSPs have opted for a measured approach by pursuing narrowly-defined goals to virtualize select network segments. The results: CSPs are faced with complexity arising for having to orchestrate and operate a mixture of legacy and virtualized network function deployments.

Another significant challenge stems from scarcity of skilled labor. Specifically, expertise in system integration along with knowledge in the design, integration, validation, and operation of a software-centric, complex SDN/NFV based infrastructure. Meanwhile, CSPs recognize the benefits of implementing open solutions to avoid vendor lock-in. However, this adds to the complexity to the task at hand – there are many vendors offering SDN/NFV-related software & hardware tools, e.g., hypervisors, vSwitches, OpenStack NFVI software, SDN controllers, VNFs, Orchestration tools, servers, leaf/spine switches. It is easy to see that selection, validation, and testing required to integrate a multi-vendor solution brings additional levels of complexity and can increase costs.

Vendors, solutions providers, or system integrators that offer system integration competence and knowledge in virtualized network infrastructures have the tools required to skillfully manage migration projects to reduce the risk and TCO while delivering faster time to market. Ideally, these companies are unbiased in their selection of system components and able to deliver solution “openness”. In practice, this translates to the need for such players to have established partnerships with companies that provide different parts of the overall solution. But even with a capable partner in tow, what is the best strategy for pursuing these types of migration initiatives?

Migration strategies can be mapped into three main categories, each requiring, at a minimum, integration, test and verification steps:

1. **Discrete, bottoms-up approach**: best-of-breed system components from multiple vendors are selected and evaluated on their own merits with interoperability testing required to ensure a workable solution
2. **Single vendor, tops-down approach**: start with a target virtualized network function (VNF), e.g. vEPC (virtualized Evolved Packet Core) and build a complete solution to support that VNF.
3. **Pre-integrated platform approach**: start with a pre-integrated, pre-tested open infrastructure system and integrate VNF(s) from multiple vendors on to that platform

This paper is focused on explaining the merits of the third approach. This approach tends to offer the best path to reducing risk, time-to-market, and overall TCO while allowing CSPs to incorporate multi-vendor capabilities. The paper quantifies the economic advantages of this strategy when compared with the first two approaches described above.

Challenges in NFV System Integration

Figure 1 shows a simplified NFV architecture stack. Although it would appear that implementing NFV is a straightforward process, a closer look reveals the many challenges/nuances that the integration team faces if they take a discrete, bottoms-up approach.

For ***N*** solution components:

1. Each component, including the "hardware resources", can be from a different vendor resulting in a long validation time frame
    a. Potentially ***N*** different vendor points of contacts, increasing the risk of 'finger-pointing' if problems arise
2. All components must be tested and verified separately and together, resulting in an O(N^2) time frame for full integration
    a. All components must go through individual and interoperability regression testing when a new component (or an upgrade to existing components) is introduced
    b. Writing scripts for component and integration-level testing can be a costly and time-consuming task
    c. For CSPs, reliability is of utmost importance. The system must prove to be highly available (6 9s) to be able to meet carrier-grade service level agreements (SLAs) and, therefore, additional design phases and extensive tests must be conducted.
3. Each component may require specialized skill sets, resulting in increased labor costs
4. Post integration and deployment, life-cycle management, e.g., executing software upgrade activities for all the components in the solution, is another costly, ongoing expense for the CSP

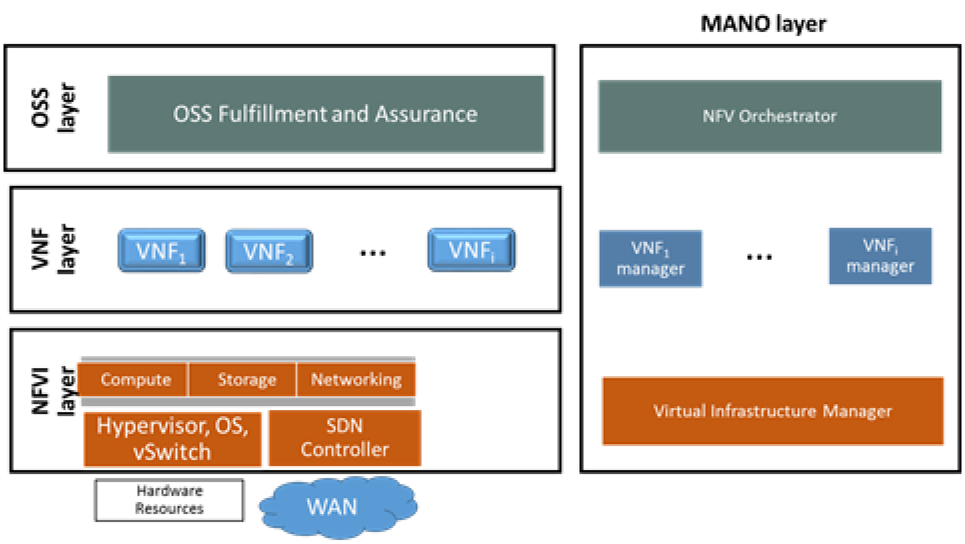

Figure 1. Simplified NFV stack

Project planning for deployment of an integrated system which includes a wide range of best-of-breed discrete components is not different from traditional methodologies. Figure 2 depicts a high level time-line for this process. Note that the total cost of deployment is directly proportional to the time it takes to deploy the integrated system.

Figure 2 depicts the Project Planning and Execution steps required to build and deploy a top-to-bottom NFV solution built with discrete components and illustrates the complexities. Note that the "Selection of Engineering Team" step itself can be a monumental task as scarcity of skilled labor can make this process very difficult.

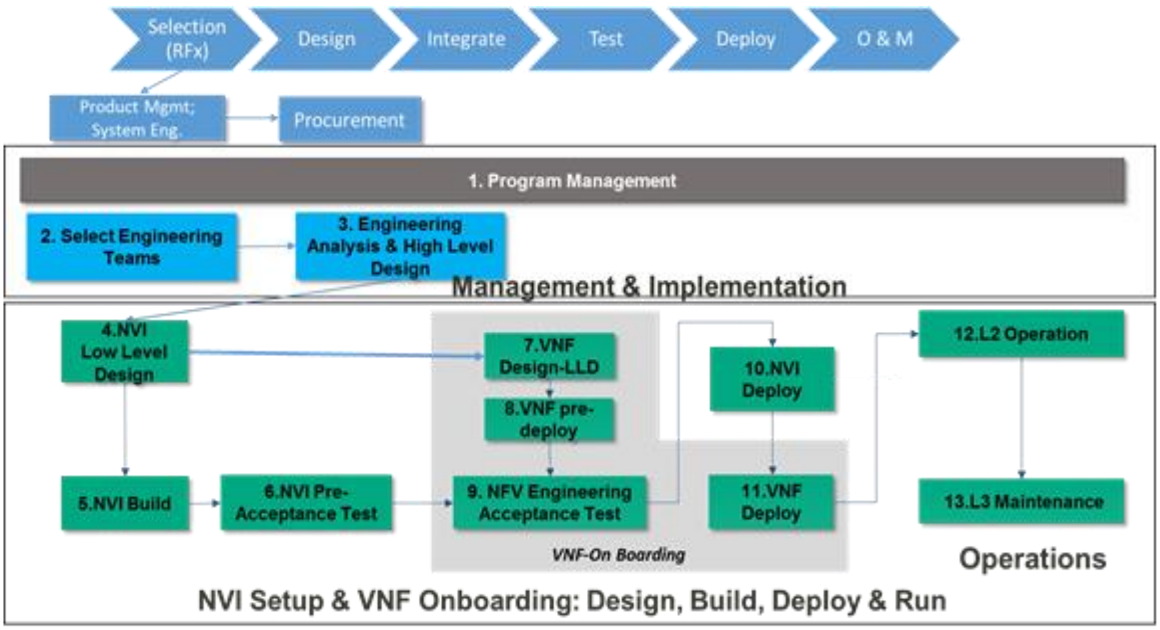

Figure 2. Project Planning and Execution

Potential complications during integration can result in increased risk and delays in deployment and time-to-market for revenue generating services. Figure 3, which tallies a typical, but not necessarily exhaustive, list of testing steps, illustrates the complexity involved in "testing" cycles of solution components:

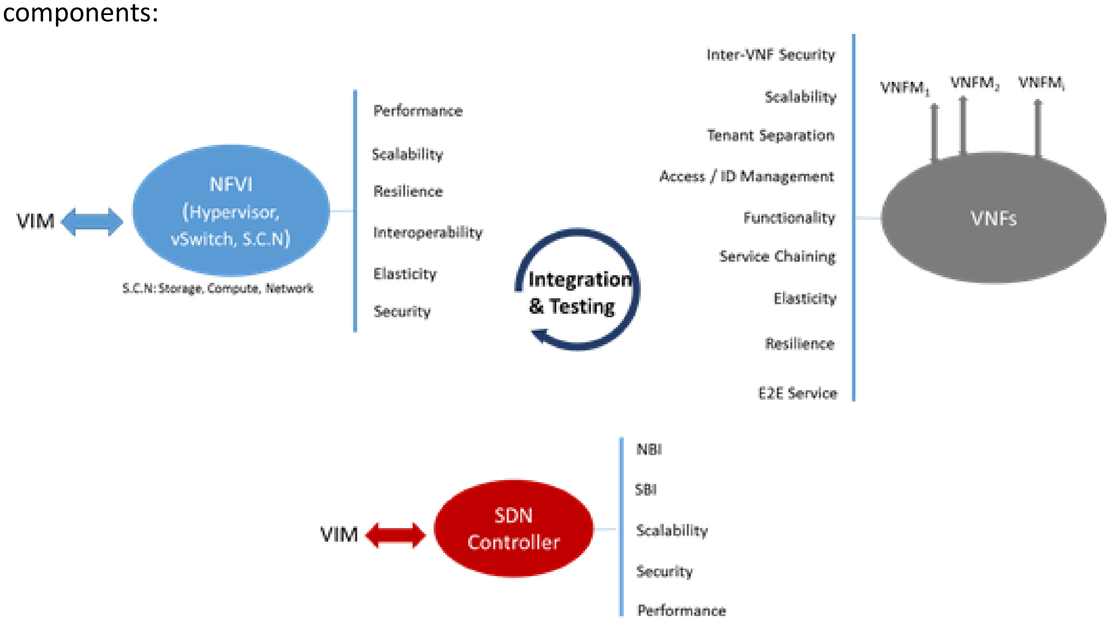

Figure 3. Integration Risk Points

Not included in the list above are the tests required for the specific target hardware and, more importantly, the orchestration Layer of the implementation (i.e., NFV orchestrator). The latter requires its own set of tests that to cover:

- Catalog configuration and management
- Provisioning (hardware and software)
- Alarms/Monitoring
- Multi-tenant management
- User/Domain Management

Furthermore, a full acceptance test must be conducted for the integrated system and any change-requirements will result in additional regression tests which will can result in further process delays.

Pre-integrated platform approach

To fulfill the high-level objectives of a CSP, i.e., maintain a competitive edge and meet its business KPIs (e.g., higher revenue levels and lower TCOs), the planning and execution activities required to design and deploy a target virtualized application must become more efficient. A class of systems is available in the market which can provide a more efficient path for deployment of a full NFV solution. These are offered in the form of a **pre-integrated NFVI system**, that provides the ability to integrate and on-board a wide range of VNFs along with other system components such as NFV orchestration tool and VNFM. To clearly define what a pre-integrated NFVI system represents, a precise definition is needed to demonstrate its potential efficiencies relative to a discrete, bottoms-up approach.

Definition of a Pre-Integrated NFV System

A pre-integrated NFV System meets a targeted set of requirements and adds value in several key areas:

- *Reduction of risk* – a pre-integrated system reduces opportunities for errors in integration test planning/execution.
- *Carrier-grade reliability* – a pre-integrated system comes pre-tested, both at the individual component and system-level, which increases system-level reliability.
- *Lower TCO* – assuming the upfront capex costs (hardware, software) of pre-integrated and non-integrated software and hardware are the same, there remains a large difference in the cost of "system rollout" or integration. Opex, which is a major TCO component, can be significantly reduced since the pre-integrated system offers lower overall life-cycle management costs, e.g., operating costs to execute software patches/upgrades and hardware upgrades.
- *Faster TTM* – reduced time required to rollout new systems translates to faster TTM.

Naturally, a pre-integrated system that delivers these benefits requires a capable vendor/partner who has system integration expertise and understands the challenges CSPs face in deploying complex virtualized networking solutions. Furthermore, the vendor/partner must have a framework for incorporating technologies from third party vendors into the system and, ideally, provide a path for bringing those technologies together with pre-integrated systems to yield complete solutions. Lastly, these capabilities must be complemented with a Telco-specific professional services offering, through which the vendor/partner can assist the CSP in completing all of the required tasks in implementing a complete solution, e.g., system design, integration, test and verification.

Discussion on a discrete, bottoms-up approach

Theoretically, building NFV solutions from scratch using best-of-breed components can offer the advantage of no vendor lock-in (figure 4). However, there are multiple disadvantages with this approach:

1. Using multiple vendors means having multiple points of contacts and consequently facing potential "finger-pointing" when issues arise
2. Having to either outsource the integration and testing to an external company or looking for and hire highly skilled, scarce engineering talent – specially to ensure 5 9s service availability requirements – can delay solution deployment and can be very costly.
3. Implementing technologies from vendors who compete in the broader market landscape, can result in conflicts and inefficiencies as CSPs try to tackle interoperation issues.
4. Misaligned product roadmaps and varying levels of support from different vendors can complicate and increase the cost of life cycle management.

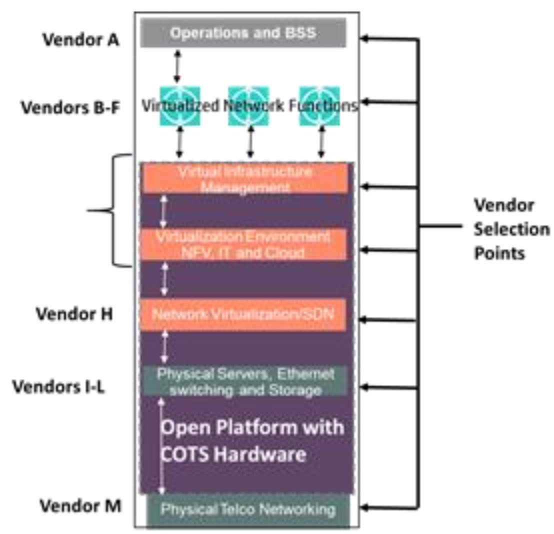

Figure 4. Best-of-breed, piecemeal integration

In contract to this approach, pursuing a pre-integrated platform approach does not necessarily mean the CSP will be locked in to vendors of those types of offers. Vendor lock-in can be avoided if the vendor/partner employs open standards in its platform architecture, providing the flexibility to isolate and replace any part of the pre-integrated platform solution as required by the CSP. Furthermore, it can take advantage of the professional services offered by the vendor/partner.

Discussion on single vendor, tops-down approach

Figure 5 illustrates this approach. In this case, the CSP selects one or more VNFs (e.g., vEPC - virtualized Evolved Packet Core) and builds the NFV platform to support it:

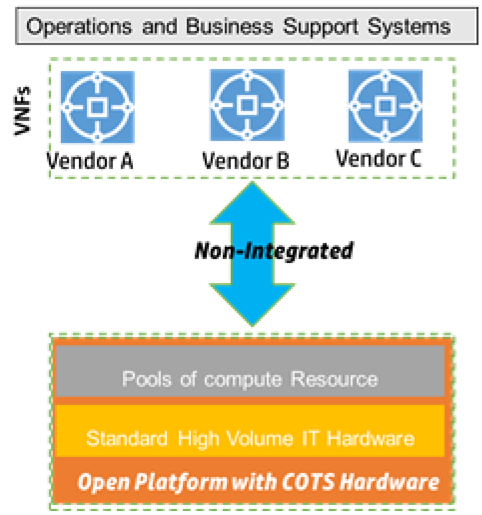

Figure 5. Top down design and integration

A VNF may have several sub-components – for example, vEPC includes EPG, SGSN-MME and GGSN. Each of these component VNFs can be sold separately or as a full stack. Other packet core functions, such as PCRF, ePDG, and IMS may also influence this top-down approach.

There are several potential challenges with a Single vendor, tops-down approach:

- The VNF vendor may propose its own stack and provide minimal to no third party integration
- Vendor lock-in is a risk, as market practices have shown that the VNF vendors attempt to impose their own pre-integrated NFVI and orchestration modules, which can effectively lock-out the CSPs from other possible solutions.
- Complex procurement cycle may occur which can result in a longer TTM, since a separate RFx (e.g., RFI, RFP, RFQ) must be created and distributed to the potential suppliers for evaluation. Further steps can include selection of the top vendors for consideration, price negotiation with each, etc.
- Typically, VNF vendors are capable of integrating their own VNFs with their own platform offerings. However, many have no demonstrable experience or process expertise in integrating VNF(s) from other vendors with their platforms

HPE Pre-Integrated NFV System

Selecting a partner with a proven track record in integrating and delivering full solutions is of utmost importance for CSPs. HPE has proven itself to be a leader in this space.

HPE's NFV system is a pre-integrated, flexible, carrier-grade platform that includes integration of several component technologies and provides a foundation for building a fully virtualized solution. NFV system starts with a robust hardware platform. HPE is a leader in providing standard-based hardware (server/networking/storage) and has a proven history in working with CSPs. Second, the 'core' NFV system includes a set of foundational software components: hardened versions of OpenStack, KVM, Linux OS, and an open vSwitch. This combination of core hardware and software components can be thought as a unified platform that is able to host multiple vendor VNF vendor applications - HPE's own

VNFs or those of its partners. More generally, HPE can help migrate existing network functions from purpose-built hardware platforms to more cost-efficient, high performance servers (see Figure 6). Lastly, HPE's OpenNFV Program includes VNFs from a wide range of vendors which have been pre-integrated with NFV System - further reducing TTM:

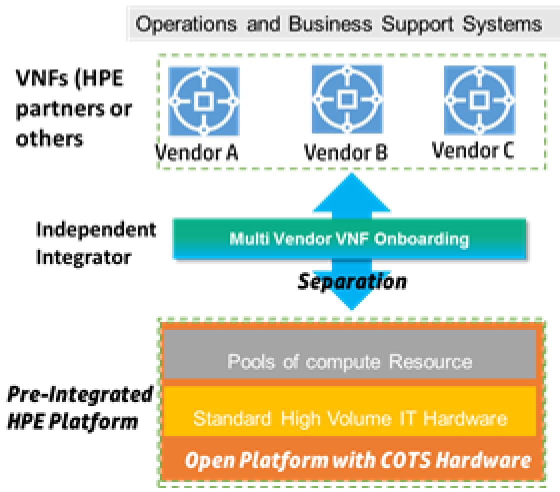

Figure 6. Independent VNF Onboarding

Figure 7 depicts HPE NFV System in detail. HPE Helion OpenStack carrier grade provides the NFVI and the solution can include HPE's Carrier SDN controller as an option. In addition, HPE's NFV Director for service orchestration can also be included in the solution to further reduce the time for VNF service onboarding. In general, all of the other system components are optionally available directly from HPE or its partners – all integrated, tested and verified for immediate deployment, and making it a future-proof infrastructure.

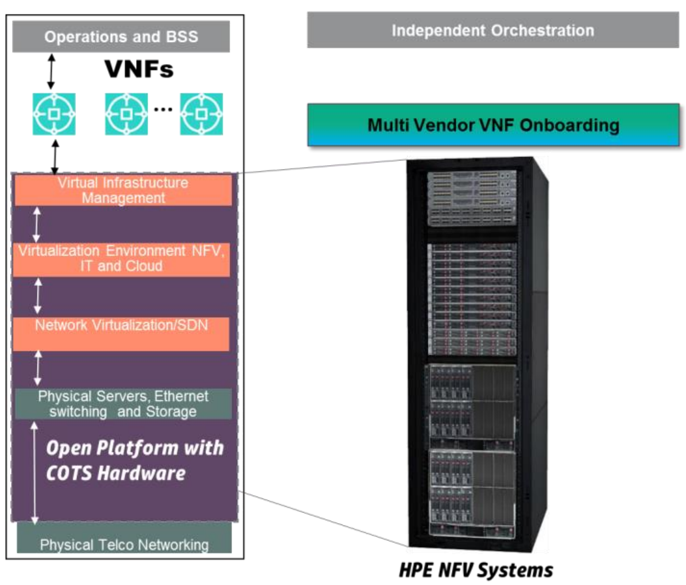

Figure 7. HPE NFV System components

HPE NFV System's flexible design approach offers the following advantages:

Field-proven, lab tested and verified platform, enabling a predictable growth strategy that advances with the market and customers' requirements.

Avoid vendor lock-in by providing the flexibility to integrate third party VNF capabilities.

TCO optimization with lower system roll-out, life-cycle management and more predictable cost levels.

Reduction of risk via streamlining integration and accelerated time-to-market (TTM)

A reliable partner that can be a single point of contact

Economics of HPE NFV System solutions

ACG Research conducted an analysis comparing HPE NFV System to do-it-yourself (DIY) solutions built from "best-of-breed" discrete components. ACG used three separate cost components to assess the difference between the two approaches: Evaluation / Purchasing activities, System Rollout, and operating costs (opex) (figure 8).

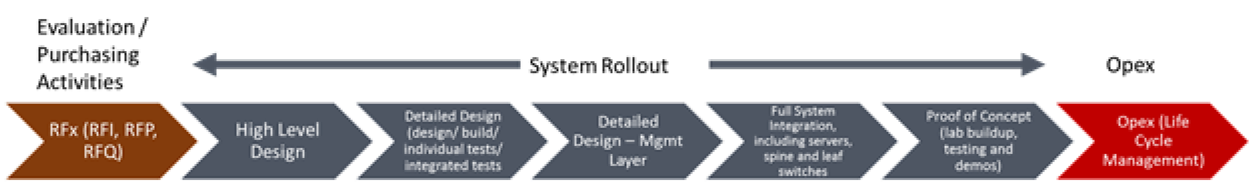

Figure 8. Detailed Tasks for NFV Integration

ACG analyzed the labor requirements for the two approaches and found that a pre-integrated NFV system yields substantial advantages in the form of lower labor cost, and faster time-to-market compared to higher opportunity costs that result from the DIY approach.

Analysis of Labor Cost

ACG further broke down these tasks into more detailed sub-tasks, shown in Table 1. Each sub-task was assigned specific teams that were required to accomplish them. ACG defined a typical team as being comprised of senior professionals consisting of Sr. Product Managers, Senior Engineering Project Mangers, System Architects, Sr. Test Engineers, VNF (vEPC & vIMS) Engineers, Sr. Hardware System

Engineer and Purchasing Managers. ACG also assumed part time participation of a management team to oversee the work. Team members in this category included Director of System Engineering, Sr. System Engineer Manager, Test Engineer Manager, and DevOp Engineering Manager. Note that in this analysis ACG did not assume a specific size for each team, e.g., for Product Management. Instead, the time that an *entire* team may spend on a specific sub-task was considered and not the time that each individual member of that team would have to spend.

Task	Sub-task	Skill Set
Evaluation /Purchasing Activities - RFx	1. Vendor Selection 2. Procurement	Sr. Product Manager; System Architect; Purchasing Manager
High Level Design	System Architecture Design	System Architect; Sr. Engineering Project Manager; Director of System Engineering
Detailed Design (design, build, individual component tests, integrated tests)	1. NFVI 2. 2xVNFs 3. SDN Controller	Sr. Engineering Manager; Sr. Engineering Project Manager; Test Engineer Manager; Sr. Test Engineer; VNF Engineers; Director of System Engineering
Detailed Design – Management Layer	1. VIM 2. VNFMx2	Sr. Engineering Manager; Sr. Engineering Project Manager; Test Engineer Manager; Sr. Test Engineer; Director of System Engineering
Full System Integration (including hardware: servers, leafs and spines)	1. VNF On-boarding 2. End-to-end Service Test	DevOp Engineering Manager; Sr. Hardware System Engineer; Sr. Engineering Project Manager; Sr. Test Engineer; VNF Engineers; Test Engineering Manager; Director of System Engineering
Proof of Concept	1. Lab build-up 2. Testing 3. Demo build	Sr. Product Manager; Sr. Test Engineer; Sr. Engineering Manager; Purchasing Manager
Opex (on-going basis; calculated annually)	Life Cycle Management O&M	Sr. Test Engineer; Sr. Engineering Manager; VNF Engineer; Sr. Product Manager

Table 1. Sub-tasks & Skill sets for integrating an NFV solution

For this analysis, team members were considered to be based in North America. Per Table 1, ACG used publicly available sources to estimate average fully-loaded salaries[1] for each team member. ACG then estimated the time each team would be required to spend to accomplish each sub-task, shown in table 1, for two separate approaches – Discrete vs pre-integrated based on HPE NFV system. Assumptions to support these estimates were based on ACG's research and industry experience.

The difference in **labor costs** for the combined first two tasks (Evaluation / Purchasing Activities and System Rollout) was found to be 61% lower in favor of HPE for deploying two VNFs (vEPC and vIMS). The **opex savings** in life-cycle management (software patches and upgrades and hardware upgrades) were found to be close to 30% lower in favor of HPE.

Analysis of Opportunity Cost

[1] www.glassdoor.com

In this analysis, ACG determined the size of each team. ACG's model was based on a typical small-medium size organization comprised of individuals with skill-sets shown in table 1. For example, ACG modeled a product management team with four members, and a Test Engineering team with six members. Each team was sized to correspond with the complexity and the magnitude of each sub-task. In this analysis, ACG assumed that for both approaches some of major tasks required serial execution while sub-tasks within each major task could be completed in parallel. Similar to the Labor Cost analysis, ACG estimated time required by the relevant team(s) to complete each sub-task.

Figure 9 summarizes the time required to accomplish each task under the discrete, bottoms-up approach – normalized to/compared with corresponding time requirements for a pre-integrated platform approach with HPE NFV system (HPE NFV System = 100%). For example, ACG analysis shows that Integration Testing of a discrete, bottoms-up solution takes over 2.4x more time when compared to a pre-integrated platform approach with HPEs NFV System:

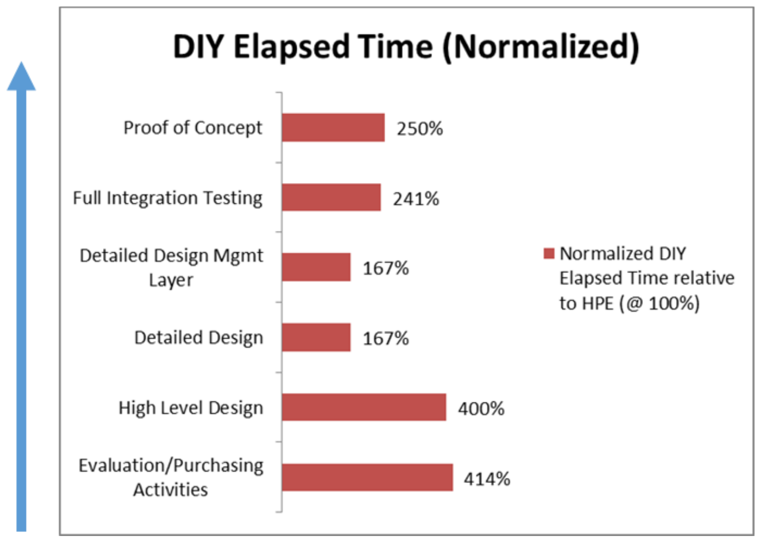

Figure 9. Relative Time Required, discrete, bottoms-up approach vs pre-integrated platform approach with HPE NFV system (HPE NFV System = 100%)

Overall, ACG found that implementing HPE's NFV System took 7 calendar months less time when compared to a discrete, bottoms-up solution - which translates into an opportunity cost of over $653K for each 10,000 subscriber lost, at $10 per ARPU.

This analysis clearly conveys the advantages of a pre-integrated platform approach based on HPE NFV System.

Conclusion

CSP's face multiple challenges as they embark on their evolution to SDN/NFV-based network infrastructures, including finding and hiring scarce labor resources and taking on the formidable tasks of integrating/testing and verifying their NFV deployments.

In comparison to discrete, bottoms-up approaches, an approach rolling out NFV solutions based on pre-integrated platforms has many advantages.

CSPs can best take advantage of this approach by working with a reliable, field-proven partner who can provide NFV platform solutions that avoid vendor lock-in. HPE, with their NFV System solution, provide CSPs a reliable platform solution that reduces cost and risk while delivering the flexibility required to accommodate a wide range of VNFs. Furthermore, HPE has the proven telco track record, extensive systems integration expertise, and professional service capabilities required to help CSPs bring network solutions quickly to market. Lastly, HPEs OpenNFV ecosystem allows CSPs to take advantage of a full range of vendor VNF offerings while enjoying the benefits of a reliable NFV platform foundation.

This paper explored the economic differences between choosing a “best-of-breed” DIY approach versus HPE’s pre-integrated NFV system. The analysis included labor costs and opportunity cost differentials between the two approaches. The analysis identifies labor and opportunity cost differences between the two approaches. ACG found that the difference in total labor costs between DIY and HPE’s to be 61% lower for two targeted VNFs (vEPC and vIMS) in favor of HPE. The opex savings for life-cycle management were found to be close to 30% lower, again in favor of HPE. The opportunity cost of using discrete components was found to be over $653K for every 10,000 customers lost due to late market entry for the same service.