Becoming an Agile Operator in a Globally Connected World

Executive Summary

Today, we are experiencing an unprecedented range of innovation in computing and networking technologies. Nearly every day, and certainly every week, we discover a new invention delivering a new **wow** moment in endpoint intelligence, application power and sheer communication capabilities.

Recent statistics put the situation in perspective.[1] In 2013 the amount of data carried by global mobile network operators was **18 times** the traffic on the entire worldwide Internet in 2000. From that baseline, mobile data is projected to grow **11 fold** by 2018 at a compound annual rate of 61 percent. In 2013, smart devices accounted for 21 percent of the world's mobile devices, but by 2018 **more than 50 percent** of devices connected to mobile networks will be smart devices. On average, smart devices generate **30 times** as much traffic as legacy devices because of the rapid expansion of smart devices and users' appetites for their applications. Globally, **more than two-thirds** of all application workloads will be processed in cloud-based data centers by 2018; the remainder will be supported in end-customer data centers.[2]

This explosion of interest in smart devices and applications has opened up a range of innovations in how computing and networking that support applications are done. There has been broad recognition that legacy computing and networking would not be agile or cost-effective enough to support the burgeoning demands for features, which has accelerated in the past few years. Legacy computing based on monolithic platform and single operating system (OS) frameworks would not support the diversity of applications required and would not scale with the efficiencies that large-scale consumption demands. Previously successful networking platforms based on tightly integrated, proprietary hardware and software designs would not evolve rapidly enough to support the scale and agility of communication required. A reimagining of how computing and networking would be done was required. This reimagining has had profound effects on both the application and communication infrastructures required to support the

KEY FINDINGS

- Relentless growth in application uptake and related traffic volumes are outstripping the ability of legacy platforms to keep pace.
- Virtualized platforms and open modular software are providing order of magnitude improvements in scale, agility and TCO versus legacy designs.
- Cloud-based applications and IT investments are delivering payback periods of less than one to between two and three years depending on the service.
- Virtualized network functions are demonstrating reductions in TCO of 40–65 percent, doubling the speed of new service deployments.
- Operators can secure the efficiencies and paybacks by starting on targeted programs of adopting the virtualized platform paradigm.

[1] Cisco Systems Visual Networking Index, February 2014.
[2] Cisco Systems Cloud Index, October 2013.

applications that users in every category of activity are consuming and will continue consuming in coming years.

These evolutions have powerful implications for service and application providers in every category: mobile and fixed network providers; consumer/residential and business services; access, metro, core; and data center/cloud service delivery infrastructures. The transformations they stimulate are critical for operators to embrace.

Virtualization: Transforming Service Infrastructures

The dominant transformation supporting this new direction has been the emergence of virtual designs in computing and networking systems. In many ways the core concepts of virtualization are not new. There have been virtual private networks and virtual LANs for almost 20 years, and mainframe computers introduced support for multiple, different operating systems running on the same physical computer in various virtual machines even prior to that. What is new is the range of virtualization being created, the breadth of its application and the pervasive effects that the adoption of the designs will have.

Nearly every function in a service that involves computation is a candidate for virtual implementation. Service providers' (SP) future infrastructures will include many elements focused on physical processes (such as radio, optical and metallic communication) that connect a near-infinite variety of control and application modules that use some form of virtual design to deliver the rest of a service's functionality.

The signature attribute of virtualization that delivers its power is the abstraction of a function's software from the details of the hardware underpinning its execution. This is made possible by intervening software abstractions (for example, a hypervisor in current virtual machine implementations) that allow multiple guest OSs and applications to run on a single physical machine and handles the nuances of how that machine actually runs under the covers. This allows software developers to concentrate on the logical attributes of what they are implementing and place their workloads wherever execution will be optimized. Whether the physical computer is from vendor A or vendor B or is a modular or fixed form-factor device is irrelevant to the software as long as the abstraction is present.

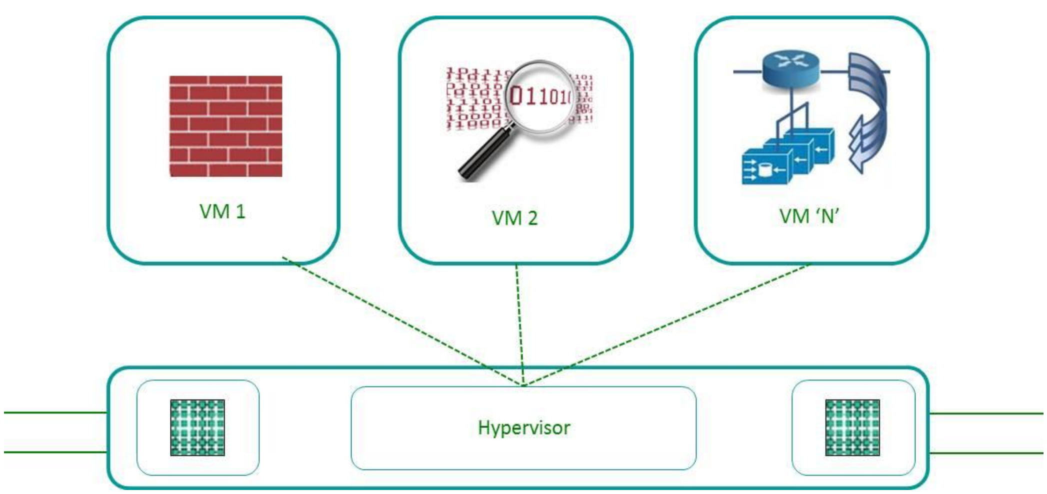

Figure 1: Individual Virtual Machines Running in a Hypervisor System on a Single Physical Server

Abstraction has provided the underpinning for the development of cloud computing, which has become the dominant method of implementing applications in nearly every domain of computing over the past several years. Everything as a Service with highly flexible consumption has become the go-to model for feature delivery. By making the environment elastic, reachable and resilient, functions can be created nearly anywhere to enhance an application or provider's offerings.

As experience has grown with this model, its application to networking has also become a top priority, as well as a significant opportunity. To break the chains of tightly coupled legacy platform designs, the concept of abstracting functions into software running on properly sized general-purpose computers has become the center of attention for improving flexibility in future networks. Not only does the model have relevance on its technical merits (its ability to accelerate innovation and agility), it also has compelling economic motivations. Estimates of capital expense (capex) savings from virtual design adoption range from 25 percent to 80 percent, depending on the area of functionality. Operation expenses (opex) and total cost of operations savings track to the middle of that range, again depending on the function. The prospects of increasing efficiencies in this manner while accelerating the pace of innovation and new service deliveries are impossible for operators to ignore.

There is a closely aligned set of areas in which the transformations relevant to operators are occurring. First, there is a burgeoning amount of work being done in cloud computing. This is creating frameworks for deploying collections of virtual machines to support everything from BSS/OSS, rich communication services and social networking to multifaceted analytics and machine-to-machine services. Frameworks for orchestrating services, such as the OpenStack Foundation's OpenStack reference implementation for orchestration of cloud computing services, and innovations in continuous operations that automatically integrate software development with resulting system operations (known as DevOps), have emerged as underpinnings for the new virtual environments. Using pools of virtual resources to support new service deliveries is fast becoming the new normal for evolution of operators' platforms.

In parallel, industry participants, including the world's 30 largest communications service providers, have undertaken a far-reaching initiative to harness the power of virtual machines and general-purpose servers to support network functions and enhanced services. This initiative is occurring under the aegis of the European Telecommunications Standards Institute (ETSI) under the name of the Network Functions Virtualization (NFV) Industry Specifications Group (ISG).[3] The ISG is a collection of nearly 200 companies addressing a range of topics needed for defining a new paradigm for more agile delivery of operators' services. Everything from use cases to reference architectures to management and operations frameworks is being defined to enable uptake of the virtualized and more agile model.

[3] White paper defining the objectives and scope of NFV, *Network Functions Virtualization: An Introduction, Benefits, Enablers, Challenges & Call for Action*, October 2012.

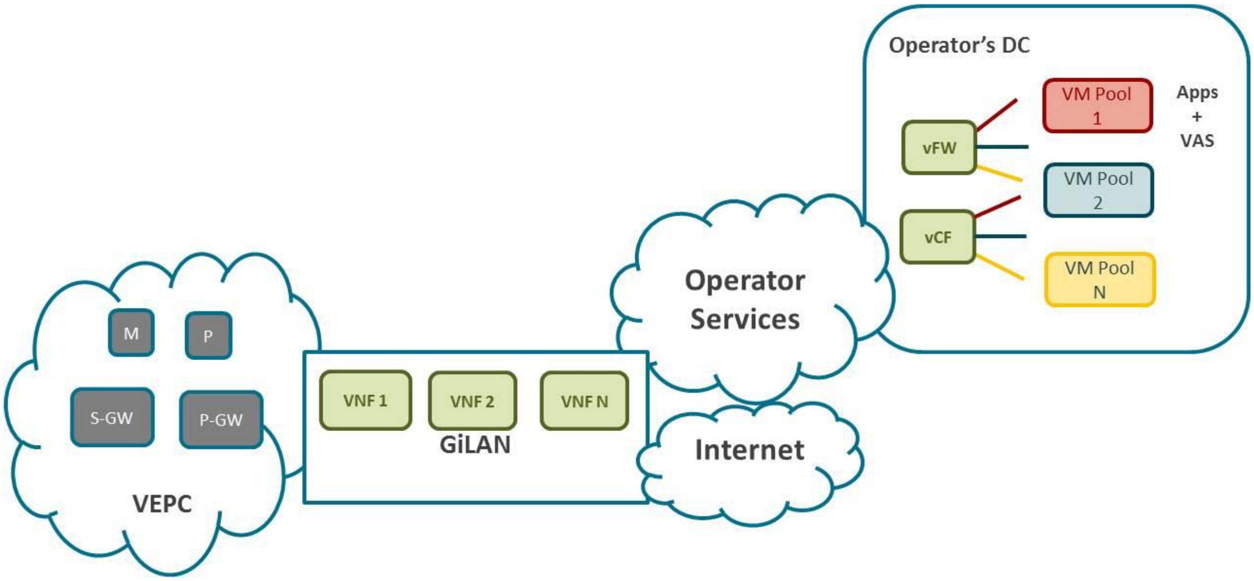

Figure 2: Virtualized Network Functions

A final evolution creating a more open foundation for future services is the development of software-defined networking (SDN).[4] SDN harnesses the principle of abstraction by enabling control plane and service-tuning functions (such as service level agreement measurement and dynamic resource allocation) to run as normalized functions centrally in an infrastructure and to be applied consistently across a diverse, multivendor range of underlying elements (routers, switches, optical transport, access nodes and others). In this manner, SDN is to networking what virtual machines are to computing with a similar set of efficiency, flexibility and innovation goals underpinning its adoption.

Benefits for operators

What are the benefits that can be realized by adopting this virtualized solution delivery path? The primary benefit categories are highlighted here, and a view of how they can be measured follows, illustrated by a set of cases that demonstrate the value of the new solution models in example deployments.

Benefits from embracing the virtual model in operators' services are achievable in each of the following areas:

- Accelerated innovation. Abstraction of functions and support for modular, open components creates expanded opportunities for innovation in local functions and adds functions efficiently to a well-designed baseline.

- Faster time to revenue. Modularizing components and reducing tight interdependencies between elements increases the opportunities for bringing enhancements to trial and market faster. This allows rapid elimination of less attractive options and quick expansion of very attractive offerings with strong uptake.

[4] Open Networking Forum white paper on SDN, [Software-Defined Networking: The New Norm for Networks].

- Ease of ecosystem engagement, growth. With open and modular platforms (versus tightly coupled proprietary implementations) it is easier to engage partners in expansion of services and markets, growing the returns achievable in a wider range of offerings for customers.

- Lower capex. By harnessing general-purpose, high-volume servers to support a wide array of virtual functions, the cost per supported service is reduced, increasing an operator's competitive position and readiness to evolve.

- Lower opex. Levels of opex are measurably decreased with increased automation in development, deployment and operations, and reduced infrastructure overhead per unit of service delivered over time.

- Enhanced customer intelligence and personalization of services. Using more open and advanced software, operators can learn more about customers' preferences and usage, supporting greater granularity in targeting and packaging, increased loyalty and higher sustained revenue levels.

- Improved return on investment (RoI). Combining innovation and agility gains with reduced total costs, higher levels of margin and RoI from well-executed transformations are within reach.

Is there evidence of the benefits achievable along this more agile path? The short answer is yes. Many pockets of information exist in materials from individual vendors and operators. Here, we illustrate benefits using three prominent cases that articulate how and why virtualization technologies create a powerful foundation for operators to become more innovative, agile and customer-connected moving forward.

Use Cases: Agility and Innovation

The first case highlights the returns that can be achieved using cloud computing to support a wide range of diverse IT workloads. The second case examines the improvements in total cost of ownership (TCO) and agility when virtual designs are used in a target area of an SP's network infrastructure, the packet core of an operator's mobile network. The third case looks at the gains from deploying an integrated mobile broadband solution, including macro cell, small cell, virtual security and policy control, and service orchestration connecting to self-service portals and BSS/OSS applications.

Harnessing the power of the cloud for diverse IT workloads

The first case highlights gains that can be achieved in a broad transformation to the cloud by one of the world's largest, most diverse data center collections used by the agencies of the U.S. federal government.[5] With an annual spend of nearly $100 billion, federal entities have a compelling reason to determine if their efficiency would improve measurably from an evolution to the cloud. The analysis evaluated the range of frameworks that would be used by the government's transformation to the cloud over multiple years. In developing a plan, the General Services Administration served as an aggregator of data and approaches on behalf of participating agencies and provided a summary of their characteristics.

[5] *The Economics of Cloud Computing: Addressing the Benefits of Infrastructure in the Cloud*, Booz, Allen, Hamilton.

Workloads and data centers were characterized according to each agency's purpose, including attributes of sensitivity, performance, technology base and geographic scope. A profile of whether an agency's workloads would evolve toward a completely public, completely private or hybrid (public/private) cloud implementation model was created. A complete profile of the economics of the transformation in each case was developed. This included investment phase costs of implementing the model and concurrently retiring assets and systems previously employed. It included ongoing costs after transformation, capturing efficiencies achieved. A cost comparison for moving forward of the designated cloud type versus the legacy mode was made. Measurements using net present value and discounted payback period of the improvements involved were taken.

The level of benefits achieved varies by type of cloud. Generally, public cloud implementations result in higher efficiency yields, and private cloud implementations result in slightly lower yields, with hybrids falling in the middle. However, the size of the benefit streams achievable in **every** cloud deployment model is significant. An average payback period (including investment/development and ongoing operations phases) of less than three years was identified for public cloud transitions, and an average payback period of less than four years was measured for private and hybrid models. The reduction in ongoing operating costs after transformation ranged from 60 to 75 percent.

In operator terms, if an investment in transformation is made for a workload (say, an application server or value-add services platform) to transition from a monolithic legacy implementation to a virtualized, cloud model implementation, the efficiency gains would recoup the investment costs within an average of one or two years of the new solution being placed into service (inclusive of investment and transformation phase costs). Some transformations would recoup investment faster, some slower, but the breadth of this implementation and its average efficiency gains are noteworthy as points of comparison.

Improved TCO in a mobile services gateway

Now, we look at how benefits compare in other parts of providers' infrastructures. A second case analyzes total cost of ownership in a mobile packet core using virtualized components versus supporting the same functions with a tightly integrated legacy design.[6]

This case analyzed the serving gateway node (SGSN and S-Gateway) and mobility management (MME) portions of 3G and 4G mobile packet cores in a mobile operator's network. Looking at the 3G and 4G solutions together in one analysis is instructive, as most operators run 3G and 4G in parallel as part of their evolution, and both generations of solution leverage MME capabilities in their own way.

An implementation for a working network supporting 10 million active subscribers over three geographic regions was analyzed. The virtualized solution implemented mobility management services using virtual machine-based software modules and general-purpose servers versus the tightly coupled appliance model of its predecessor solution.

[6] *Business Case for Juniper Networks Virtualized Mobile Control Gateway*, ACG Research.

The virtualized solution required **53 percent lower capital expenditures** than the monolithic design. Operational expenses of the virtualized nodes, which included power, cooling, space, training, installation and deployment, and ongoing operation, were **65 percent lower** than the legacy design. From the service agility perspective, the cost of deploying new capacity in the virtualized platform is **less than one-half** the cost of performing the same activities in the monolithic design. The virtualized solution model reduced the underlying costs of ownership of this service delivery platform and increased the efficiency of adding new service functions and locations.

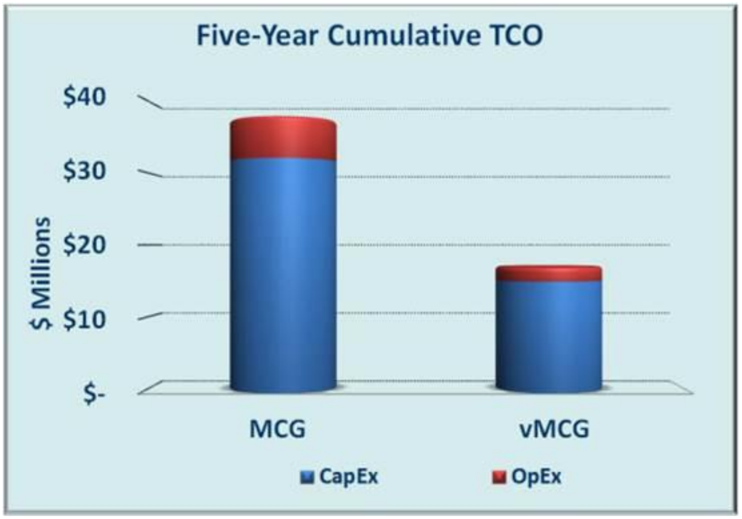

Figure 3: Five-Year TCO of a Virtualized Versus a Legacy Implementation of an SP's Mobile Control Gateway

TCO improvements in an integrated mobile broadband service

A third case illustrates how the improvements highlighted in the prior node-oriented case can be expanded to apply to an operator's integrated broadband service that incorporates a wide range of components, including macro cell, small cell, Wi-Fi, appliance (security, policy) and orchestration/service management.[7]

The industry context for this case is that users' appetites for consuming mobile services are crossing network boundaries regularly, meaning unified support for subscribers, devices and applications across 3G/LTE, small cell and Wi-Fi networks is a capability that will be highly valued by subscribers in coming years. Each of those infrastructure environments has its own implementation, and the task of supporting them in a cohesive manner—from network node to BSS to customers' experiences—can involve many levels of complexity. It is a scenario ripe for use of modular, integrated policy and control; consistent subscriber profiles and context-sensitive entitlements across the various domains; and integration with open, flexible orchestration and management systems in a cloud-based design.

This case compared the total costs of ownership of a design for the service that uses segregated silo solutions for each component with a design that uses virtualized, modular node and control plane components for each network function, virtual implementations of security and policy control capabilities, and an orchestration system implemented in a cloud-based deployment model.

[7] *Business Case for Cisco Evolved Services Platform and NFV*, ACG Research.

When comparing the two alternatives, the TCOs of the two most heavily influenced portions of the implementation (the EPC and the Gi LAN between the operator's network and the Internet at large) were 43 percent and 44 percent less, respectively, than their conventional platform alternatives. Depending on the operator, this equates to deploying nearly twice as many service areas in the same timeframe with the virtualized versus the monolithic design or to scale new offerings nearly twice as efficiently as was possible before while simplifying the management of subscribers' profiles and subscriptions across the diverse network environment.

Lessons of Early Developments

What lessons can we extrapolate from these early implementations that can help determine adoption and service innovation plans? How can we start down the path of turning this broad and latent potential into results? A few high points stand out that can help in forming a well-considered plan.

- The probability of significant benefits from embracing the virtualized path is high. Evidence of cost reduction and accelerated innovation in services and applications is strong. A superior method of developing and delivering services is within reach.
- Opportunity costs are high, and getting started matters.
- Start with modest implementations, clear scopes and clear metrics for success.
- Pilot implementations tend to generate multiplier effects. If a pilot achieves its goal, it is likely that lessons learned can propagate to additional implementations and teams, accelerating the pace of improvements.
- Picking cases that can expand in measurable, incremental steps can help. If an environment (say, a Gi LAN, a BNG gateway or a rich communication services platform) can be transformed in manageable, incremental steps, building on the success of earlier stages, the transformation is more likely to accomplish its goals and build confidence in the designs than a one on a path that can only move forward with massively sized implementations.
- Reuse of design baselines for new enhancements multiplies benefits. Sometimes the same module can be deployed in a new region or area. In other cases, the modularity of open systems will allow a minor adaptation to accomplish the extension.
- Harnessing an orchestration model that uses abstractions, templates and open software architectures for integration with multiple applications, partners and infrastructures will pay dividends.

Choosing Where to Start and Planning to Expand

With so much potential for progress in clear view, where does one begin? There are two strong, general-case targets that are focused on virtualized network infrastructures, and a third presents itself as a natural outgrowth of the cloud for application services.

In the near term (one to three years) the network edge is a prime area for deployment of virtual platforms to handle the growth in bandwidth per user, which is driving requirements for scaling and agility. This is the point at which users' traffic is routed and handled according to service profiles to which they have subscribed. At this location in fixed and mobile networks, decisions are made about security, content delivery, quality of service, access control and other functions, using modules that are perfect candidates for transformation to virtual designs from prior implementations. In these areas, it is possible to choose a service function (say, policy enforcement for traffic steering to value-add services or security inspection for malicious traffic prevention) and transition **just that function** to a virtualized implementation as part of a transition plan. Guidance in the near term can be found from the use cases and specifications being developed as part of the ETSI NFV working groups (as one plausible reference). A strong example being enabled by Metaswitch Networks is virtualization of session border controls in IP multimedia services. Gains from implementing a virtualized SBC such as the Perimeta SBC are being borne out in early testing in forums such as EANTC's NFV Showcase at the 2013 NFV and SDN World Congress.[8]

A second area with near-term potential is in orchestration systems used for cloud computing and infrastructure configurations management. Orchestration systems can run in both cloud computing data centers and remote computing pods of various sizes. Modestly scoped implementations can be chosen at the start by focusing on, for example, hosting virtual machines in a business Infrastructure as a Service offering coupled with business virtualized private networks or supporting portions of a rich communication services application that are amenable to running in a virtual machine environment parallel to the rest its components. Beginning to transform to a model in which components of services will run in their own virtual resource pools is an area where initial gains will only grow.

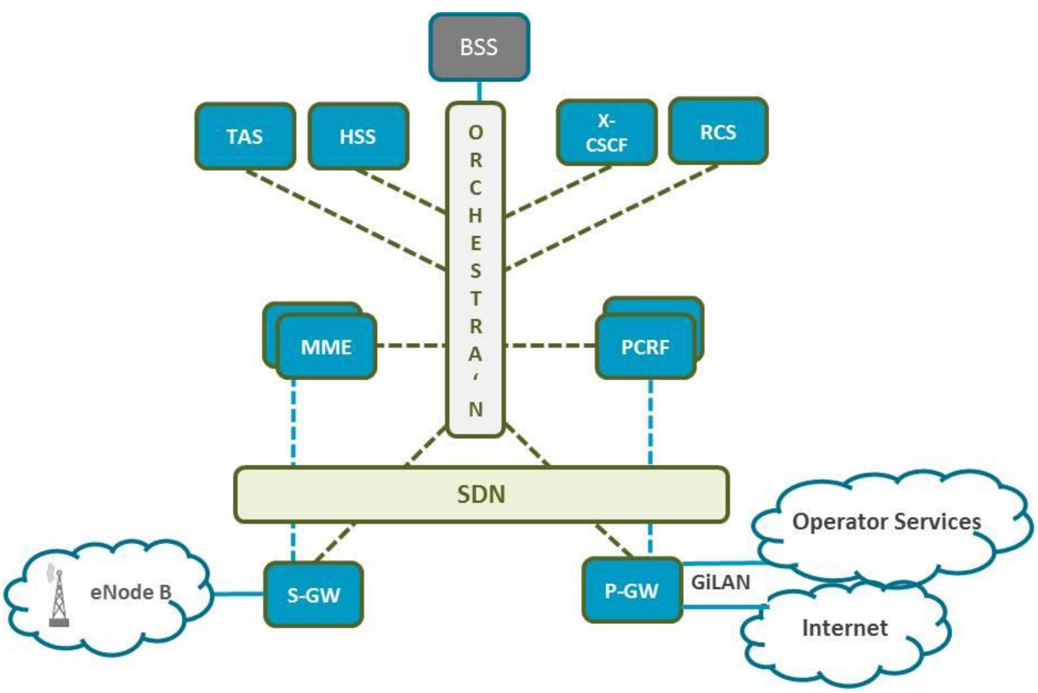

Figure 4: Choosing Offerings to Enhance with Modular Service Orchestration Systems

[8] *NFV World Showcase 2013: Provisioning, Portability and Elasticity*, EANTC.

A final area where early-stage initiatives make perfect sense is in an operator's application offerings, where new features for a service are being planned or completely new service offerings might be developed. Functions could be social networking additions to existing applications, content categories added to an existing service, analytics added for evaluating opportunities in a subscriber group, and many more. All are natural candidates for harnessing the power of virtual platforms to increase flexibility and scale. The same guidelines about narrow scopes and clear metrics for success that apply to the other project types can be applied to these as well. A forward-looking example of how the openness and elasticity of a virtualized application platform can serve as the baseline for an innovative range of communication and social networking services is European operator Tiscali's use of the Metaswitch-supported Clearwater open-source platform as the foundation of its Indoona application services.[9]

Profiting from the Model

With the prospect of benefits from virtualization being as broad and substantial as the early evidence shows they can be, the primary imperative for an operator's team is to choose the areas in which early implementations can be trialed, aligning those targets with a coherent vision of how service offerings might evolve moving forward, and building on the progress achieved. The track record of cloud and virtual platform implementations to date has shown that remarkable acceleration of innovations and new service developments can be achieved in fractions of the time previously required to deliver functionality. The relative efficiencies in deploying and scaling the solutions that gain traction allow for an order-of-magnitude improvement on total costs of operation.

With well-considered choices on early deployment targets, operators can proactively join the ecosystem of innovators engaged in expanding the range of solutions end users are consuming, and evolve toward full-scale participation in the virtual services age.

[9] *Tiscali Goes over the Top With Metaswitch's NFV*.