HEAVY READING

White Paper

Unlocking Network Value: Service Innovation in the Era of SDN

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Introduction

Network owners face huge challenges as a growing and unpredictable deluge of digital services stream across their networks. The gap is widening between the revenues communications service providers (CSPs) can drive from their existing services and the network investments they need to make to support service users' rapacious appetite for capacity. And since digital services increasingly run over the top of networks, CSPs are finding it difficult to establish a role for themselves as valued partners in the new digital economy.

A large factor here is the inflexible architecture of the network itself, which is slow and costly to change. Today, CSPs have limited ability to launch new services in the network or to adapt the network to support new service needs. While digital service developers can take advantage of highly flexible and dynamic software technologies to drive rapid innovation, CSPs are constrained by existing network hardware and software as well as growing network complexity, preventing them from creating differentiated services of their own and/or monetizing innovative approaches to service delivery.

This white paper argues that software-defined networking (SDN) will enable CSPs to create new services that fully leverage their network assets. SDN also promises to help CSPs deploy and manage services quickly and easily. SDN is therefore key to the development of new sources of revenue for CSPs.

There is more than one way of achieving a SDN and several different avenues for service enablement that a CSP can pursue, as this paper explains. SDN is expected to enable the rapid creation and deployment of new, intelligent network services by providing an abstracted (logical) view of the entire network, end-to-end, which can be programmatically changed and customized to meet the needs of individual users and services. Services themselves will be composed from "chains" of reusable, in-network service components and analytics will play a large role in programming the network "on the fly" to meet service needs. A new management layer for SDN will provide a single, orchestrated touch point for all services, accelerating their onboarding and management and enabling applications to be brought to market faster.

This paper suggests that SDN's impact on service innovation will be twofold: It will enable CSPs to build new services within their networks and it will be the basis for a new developer ecosystem, unleashing the creativity of a wider pool of third-party talent and supporting a revenue-generating dialog between the network and digital services from the Web 2.0 world.

This white paper describes early examples of SDN-based service innovation that are already being developed, tested and in some cases implemented, by network owners and vendors. These examples include: enriching existing connectivity services with self-service customized connection parameters, optimizing video delivery with a centralized and virtualized intelligent traffic steering function and dynamically customizing the delivery of bundled enterprise and consumer applications from the cloud.

Many more innovative SDN-based service scenarios will emerge over time, helping CSPs unlock further value from their networks, drive new services revenue and insert themselves into the digital economy as critical service delivery partners.

Adapting Network Innovation to the Pace of Business Change

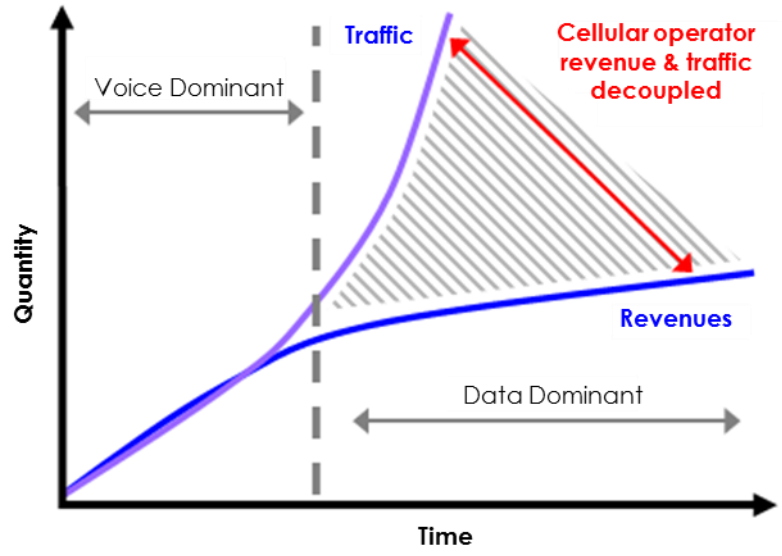
Drivers for Innovation

The list of new technologies driving ever greater access to information is exploding, from the Internet, cloud and smartphones to social networks, analytics and M2M devices. The availability of information is closely linked to the speed of innovation, and this virtuous circle is spinning ever faster in the modern world. As the pace of innovation picks up, so does competition and the need for business change – affecting both enterprise customers and their service providers.

One of the most visible manifestations of accelerating innovation is the growing volume of digital services being delivered across the world's networks. The number of mobile apps alone is racing toward the two million mark. The extraordinary level of over-the-top (OTT) software innovation is transforming the life and workstyles of people across the planet. But the owners of the networks that this dynamic deluge of digital services are running across face enormous challenges.

According to Cisco's Visual Networking Index, annual global IP traffic will be 1.3 zettabytes by 2016, with the increase in global IP traffic between 2015 and 2016 alone being almost equivalent to the entire amount of IP traffic carried just four short years earlier, in 2011. Cisco forecasts that worldwide mobile data traffic will increase 13-fold to 2017. Yet a reading of the annual reports of many major network-owning service providers shows that their revenues and profits from existing services are not rising in line with these massive increases in traffic. A widening gap is appearing between CSPs' revenues and the large sums needed to invest in their networks to support growing demands for capacity, as shown in **Figure 1**.

Figure 1: The Decoupling of Revenue & Traffic



Source: Heavy Reading

This is leading to two major challenges for CSPs:

- How can they introduce into their networks a new wave of innovative services to boost revenues and margins?
- How can they monetize the third-party services that are appearing on their networks at ever increasing scale?

CSPs want to establish their relevance as a valued service supplier and partner in the new digital economy. They are looking at ways of developing and launching new services quickly and cost-effectively and they would like to have the business and technical agility to address new application requirements and business partnerships as these arise.

CSPs also want to improve the customer experience of the digital services they deliver, whether these are their own or third-party services. They are struggling with the unpredictable traffic growth associated with such services and the risk of losing revenue. Customers are becoming increasingly fickle and prone to churn if they don't receive the experience they expect – for example, from video services. CSPs recognize that managing digital services in an optimal manner is itself a service opportunity.

The Case for Network Change

It is clear that to meet these challenges network owners cannot continue with their current approach to building and operating networks. Digital service developers are taking advantage of highly flexible and dynamic software technologies to drive rapid innovation, but beneath them the network remains static and difficult to change. The network also cannot easily communicate with the applications that ride on top, barring network service providers from realizing new opportunities to monetize innovative approaches to service delivery.

The network is a powerful source of value for CSPs, but the way it is currently engineered and operated means that its full potential remains untapped. CSPs must drive more value out of their network investments and match the pace of innovation in the network with the speed of digital services invention. They must find a way to create and enrich new classes of service (CoS) that leverage their network assets, ensuring that such services can be deployed and managed quickly and easily to generate new sources of revenue.

CSPs therefore need a means of:

- **Creating** new network-based services using similar concepts and technologies to those that have transformed Web software development
- **Enriching** services of all types – existing services, OTT services and new services, whether in-house or external third-party developed, with new sources of information (intelligence) derived from the network
- **Deploying** new network-based services in a rapid, agile manner, using simplified management tools to reduce cost and decrease time to market

Network owners are most likely to uncover valuable opportunities for network-based innovation in the business-to-business (B2B) market. Here, there are a number of possibilities for helping enterprise customers and OTT service provider partners become more competitive and efficient. Enterprise customers are themselves struggling with rapid business change in a tough and highly competitive economic climate. They are looking for service provider partners that can help them use network resources and services more cost-effectively, offer innovative pricing models and drive new levels of end-customer engagement.

To maximize this opportunity, network owners must be able to roll out new services, such as network-enabled cloud services, network analytics-based services and application-aware network services, without having to re-engineer the network every time they do so. They will also need to monetize new services on a huge scale, managing customer-specific, differentiated in-network services for hundreds or thousands of B2B customers with millions of end users.

SDN: The Enabler for Network Innovation

Defining SDN

SDN has been identified as a new approach to networking that that will foster high-value, network-based service innovation. But what does this much-debated acronym mean?

While there are specific definitions of SDN that focus on the separation of the control and forwarding planes of the network, especially in the data center, *Heavy Reading* supports a much broader interpretation of the term. *Heavy Reading* understands SDN to mean the extraction of network functionality, whatever form this takes, whether control, service or management-related, from physical appliances into software. And although SDN started in the data center, *Heavy Reading* suggests that SDN is a cross-network goal – encompassing the LAN, WAN and RAN and Layers 1-7 of the network stack.

While the physical network is difficult, fragmented and time-consuming to change, typically requiring manual intervention, a software-based network will be seamless and flexible. The vision for an SDN-enabled infrastructure is that it can easily be changed through programming; a further advantage is that programmatic steps can be automated. SDN will enable the entire network to be managed as a single entity, orchestrating provisioning, for example, across functions, devices and layers of the network, and providing a real-time view, informed by network analytics, of network performance and availability. In this way, SDN breaks down the operational silos that are one of the largest obstacles to the rollout of new network services today.

If the network has programmatic interfaces, then applications can talk directly to it, in contrast to today where services are unable to communicate with physical network elements. Services can then instruct the network about their needs – for routing, security, performance, etc. – and SDN technology can program the network accordingly. This communication can be *bi-directional*; so through programmatic interfaces, the network can inform applications with a wealth of detail, for example, about its state, the presence and location of subscribers, and intelligence derived from network analytics. Application-to-network communication opens up huge potential for service innovation.

Once network functions are realized in software, decoupled from underlying hardware, they can take the next logical step and become *virtualized*, able to run in virtual machine environments and even the cloud. This is the aim of the Network Functions Virtualization (NFV) initiative, which is closely associated with SDN.

Three Approaches to SDN

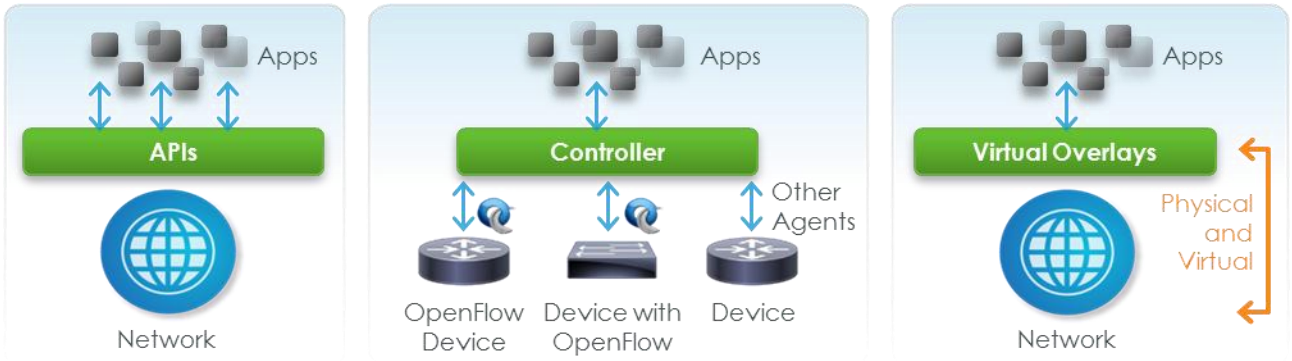
Although this paper focuses on the impact of SDN on the potential for and speed of service innovation, it is important to look briefly at the different technology approaches for achieving a programmable SDN. These approaches include:

- **Abstracting the network through application programming interfaces (APIs).** The abstracted view of the network is similar to the IT concept of a service-oriented architecture (SOA). Network functions, whether they remain locked into hardware or are realized as (virtualized) software systems, represent "services" that can be called through APIs. The network appears to

be fully software-defined because it is abstracted and can be manipulated in software – even if, under the covers, it retains physical elements

- **Abstracting the network through the concept of a "virtual overlay."** A virtual overlay is a logical representation of the network that hides the way it maps onto physical network infrastructure.
- **Re-architecting the network to work with an SDN controller or controllers.** An SDN controller is a software-based and potentially virtualized single point of network control, management and orchestration. It supports an abstracted view of the network and works with "agents" that instrument the various virtual and physical network elements under its control. The market is still deciding whether there should be one or multiple federated SDN controllers for different layers of the network/network functions.

Figure 2: Three Approaches to SDN



Source: Cisco

These three approaches are complementary and a network owner might wish to use any or all of them to "software-define" their networks, depending on the level of investment in their existing networks and/or operational and business priorities.

Introducing SDN in an Incremental Way

It is clear that SDN approach(es) will need to be implemented gradually – in a step-by-step, non-disruptive way – to support new services. SDN must be an evolution of the existing network because of the extent to which it affects not only the physical network but also its operational and billing systems.

It is likely that the first iterations of SDN will abstract the network as an overlay/set of APIs on top of the existing physical network, avoiding the need to rip and replace current architecture and investment overnight or to disturb current operational paradigms. If network owners adopt an API approach to SDN, they should ensure that API development is carried out within a framework so that valuable and/or urgent service innovation scenarios are addressed first, while further APIs and extensions for differentiation are developed over time.

Network owners may also choose to start their SDN journey by implementing new network functions, such as video optimization, in an SDN model, as and when they introduce such functions to their network. In this way, they will gradually build up

an SDN capability that they can use to deliver innovation more rapidly to enterprise customers.

Network abstraction approaches will eventually need to work with current – very different – network domains, such as the data center and the WAN, as well as their associated operational systems, including provisioning, assurance, policy and charging platforms. SDN advocates the centralization and automation of the management layer that will initially need to be integrated with multiple operational silos.

In time, as a new management layer for SDN becomes the single touch point for new services, it will be quicker and easier for network owners to onboard those services and to reconfigure the SDN in response to service change. The SDN management layer will provide an accurate picture of the state of the network in near real-time, a prerequisite for automated, bi-directional communication between applications and the network.

Software-based network abstraction is a natural candidate for the cloud. Hosting services using SDN concepts in the cloud not only reduces their operational costs but also boosts the speed at which new virtualized network services can be created and launched.

A key advantage of abstracting the network is that customer applications and network services are insulated from the complexity of underlying architectural, protocol and/or platform changes in the physical network. Network owners will then be able to evolve their networks underneath the abstraction layer over time, and at a pace to suit their business, while maintaining the ability to innovate rapidly on top.

How SDN Enables Network-Based Service Innovation

To summarize, SDN enables the rapid creation and deployment of new, intelligent network services by providing:

- An abstracted view of physical (and in the future, virtual) network elements, which, because it is realized in software, can provide a seamless, unified and cross-domain view of network features and functions
- Bi-directional, programmatic interfaces to the abstracted network that applications can use in innovative ways
- An ability for new applications to be composed from multiple network functions, based on physical and/or virtual network elements that are exposed as services through APIs. Services are *orchestrated* through their APIs to create new applications – a process of service/API reuse that mirrors rapid service creation on the Web
- Embedded analytics that can be used to create new services and/or enrich existing applications through programmatic interfaces
- A new management layer for SDN that provides a single, orchestrated touch point for all services, accelerating their onboarding and management and enabling applications to be brought to market faster

SDN-Driven Service Innovation: What Will It Look Like?

Heavy Reading expects SDN-driven service innovation to take two forms:

- **Internal innovation:** Network owners will use their knowledge of their networks to create new services for B2B customers
- **Ecosystem-driven innovation:** Network owners will open up selected programmatic interfaces to their networks to third-party independent software vendors, creating ecosystems of application developers interested in using network intelligence to enrich their applications or in building new applications that use the network in ways not foreseen by network owners.

Internal Innovation

Internally, network owners must rediscover, or grow, a talent for service innovation based on the new opportunities SDN will provide in their networks. Network owners are best-placed to understand their own networks and the needs of their B2B customers and how they can combine the two to drive new value.

Encapsulating network features and functions as abstract "services" accessible through APIs will enable network owners to take a service-oriented approach to service creation. Network functions – "services" – can be reused in innovative combinations and "chained" together – or orchestrated – into, for example, customer or application-specific services.

The concepts of reuse and orchestration are key to rapid service development in the Web 2.0 world and can similarly be used to accelerate service creation in the network environment. Network owners can potentially create chains of services that are tailored for specific applications and/or customers, "surgically" inserting specific services into the chain when they are needed and removing them when they are not. Eventually, automation and the cloud will support SDN in spinning up and tearing down service chains on demand.

Network owners will also be able to innovate on pricing, monetizing service chains in flexible ways, introducing new business models around the consumption of services and tailoring pricing dynamically for individual customers.

Ecosystem-Based Innovation

Network owners can further drive value from SDN by opening up their abstraction layer and service APIs, under controlled and secure circumstances, to third-party partners. Third-party developers can then create new services/service chains in network owner-controlled ecosystems that parallel revenue-sharing digital services ecosystems in the Web 2.0 world.

The two levels of ecosystem may also cooperate in the future for mutual benefit. For example, applications from the OTT world might extract intelligence from the network through SDN-based APIs, using it to enrich their function and/or user experience. Third-party applications might be allowed to instruct the network directly, using pricing, quality of experience, device, content, subscriber data plan and other policies to ask the SDN to configure service chains that meet their needs.

Network-Based Service Innovation Scenarios

Early examples of SDN-based service innovation are already being developed and tested by network owners and vendors. These include:

- Enriching existing connectivity services with self-service customization capabilities, for example, dynamic control over capacity utilization and/or SLA guarantees
- Turning embedded network functions (e.g., firewalls, security) into customer-controlled and configurable services
- Optimizing video delivery with a centralized and virtualized intelligent traffic steering function
- Dynamically customizing the delivery of bundled enterprise and consumer applications from the cloud
- Using analytics to monitor and predict customer behavior and to assess the state of the network; then automating the upselling and pricing of network services, such as temporary bandwidth expansion; mobile call/data download offers

Many more scenarios will emerge over time, especially as new network-based developer ecosystems are established. In the following pages, Ciena, Cisco and Skyfire expand on some of the service innovation scenarios achievable today.

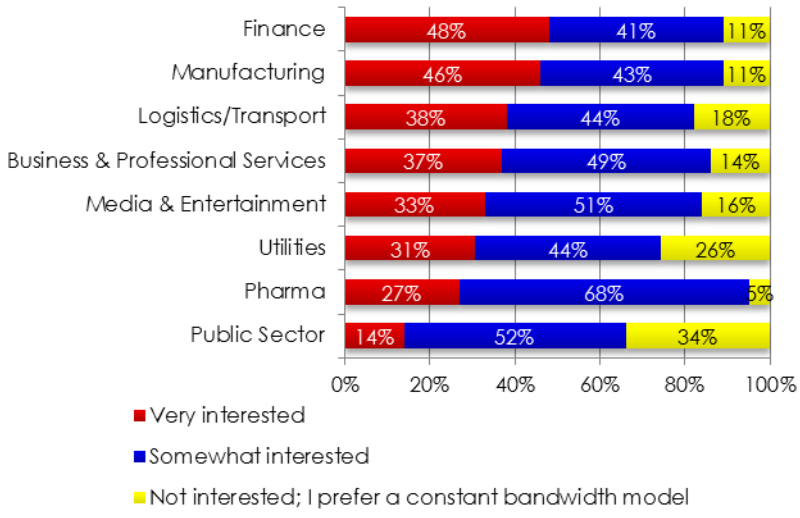
Vendor Perspectives: Ciena

SDN Drives Better Network Monetization: Enterprise NaaS

One of the most powerful features of the canonical SDN architecture, as defined by the ONF, is that the control layer has both a global view of service demands coming from the applications layer above, and a global view and global control of resources and state in the network equipment layer below. In effect, global views of network demand and supply meet in the control layer. This enables data-driven, computational intelligence, resident in the control layer, to closely match evolving demand and allocated supply on an ongoing and automated basis. This is key to network physical resource optimization in a dynamic service demand environment, but it also allows more effective monetization of the network, as shown by the example of enterprise network-as-a-service (NaaS).

Today, enterprise network services are generally limited by network planning, provisioning and service management operations processes to static delivery paradigms. These are becoming increasingly unsatisfying as, for example, enterprise WAN traffic evolves to include greater inter-data center traffic, both among internal data centers and in connection to one or more provider clouds. Such inter-data center traffic is increasingly transactional, and both time-varying and heterogeneous in terms of connection maps and performance requirements. Static connection services are thus increasingly mismatched to needs, as they are increasingly either generally under-utilized – at customer or provider cost – or periodically under-dimensioned, leading to unpredictable application performance. Enterprises want service providers to offer more on-demand connection service attributes (see **Figure 3**). More user-driven customization of connection services would support consistently better matching of supply and demand, maximizing what economists call "joint economic utility" between seller and buyer. For the service provider, that means more revenue per resource dollar.

Figure 3: Interest in NaaS Is High & Rising Across Enterprise Segments



Source: 2012 Ciena-commissioned survey

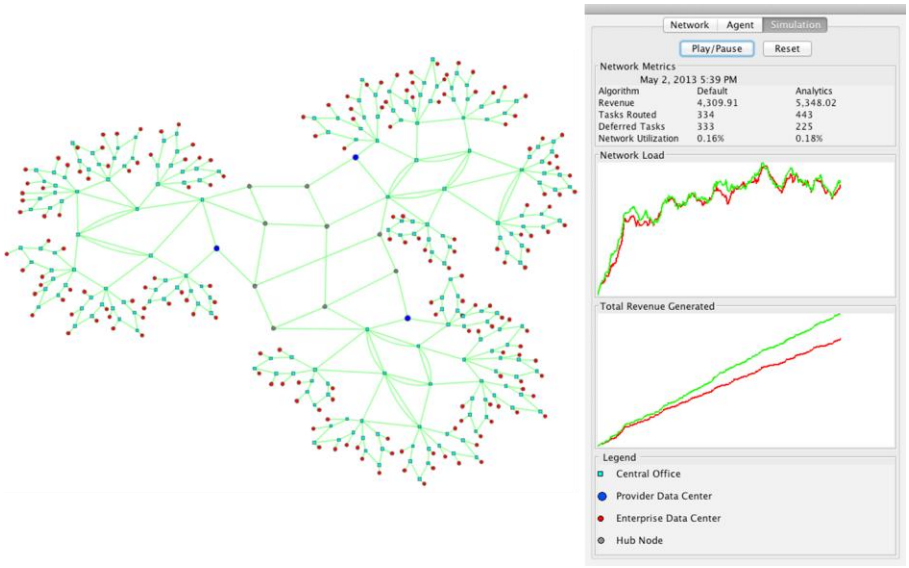
SDN is key to taking carrier services in this improved direction. As a fundamental matter, SDN allows a packet optical network infrastructure to be used both *flexibly* and *manageably*. It creates – structurally – the opportunity for computationally and data-driven, automated operations intelligence to manage and monetize the *flexible* use of network physical resources. One analogy is a parcel delivery service, such as FedEx or UPS. These services use the same fundamental physical infrastructure as classical postal systems – sorting stations, trucks, etc. – but by using them more flexibly, supported by sophisticated operations intelligence, they are able to support richly monetizable, mass-customized delivery services directly configured

by customers in response to changing individual needs, while constraining the fleets of trucks and other resources needed to deliver.

In an SDN environment, many connection service parameters – flow and endpoint identifiers, bandwidth, latency, connection quality and availability, start/stop time, price, etc. – can be independently set, and differentially and dynamically optimized, under direct customer or customer software system control. Ultimately, such differentiated "delivery orders" can be mated to multiple, resolved customer traffic flows per port-to-port connection. This provides for greatly richer connection service monetization potential than existing service paradigms. Revenue improvement with improved cost containment has a double impact on the service provider's bottom line.

Ciena is at the forefront of helping service providers unlock the power of mass-customized enterprise NaaS. Ciena's V-WAN software abstracts and virtualizes multi-layer provider networks and enables direct application-to-control system interlock for user- and application-driven automated provisioning. It maintains and bridges global demand views and supply control to facilitate the application automated operations intelligence in support of highly monetizable NaaS. **Figure 4** shows an example of the impact of such automated operations intelligence. Here, an embedded, computational dynamic pricing engine takes account of time-varying network utility factors, resolved and predicted customer needs and willingness-to-pay profiles, and varies network service pricing dynamically to maximize revenue. With no operational burden or cost to the provider, flipping the "on" switch on this software significantly improves generated revenue in a cloud connection and backbone service environment. Other real-time analytics software under development focuses on resource optimization – satisfying the most service requests from the lowest-cost set of network physical resources, and deferring incremental network capital investment as far as possible without reducing profits. These are only some of the business-impacting possibilities of real-time analytics in an SDN environment.

Figure 4: Ciena's V-WAN Control Software, With Real-Time Analytics Supporting Automated Dynamic Service Pricing for Revenue Optimization



Source: Ciena

Vendor Perspectives: Cisco

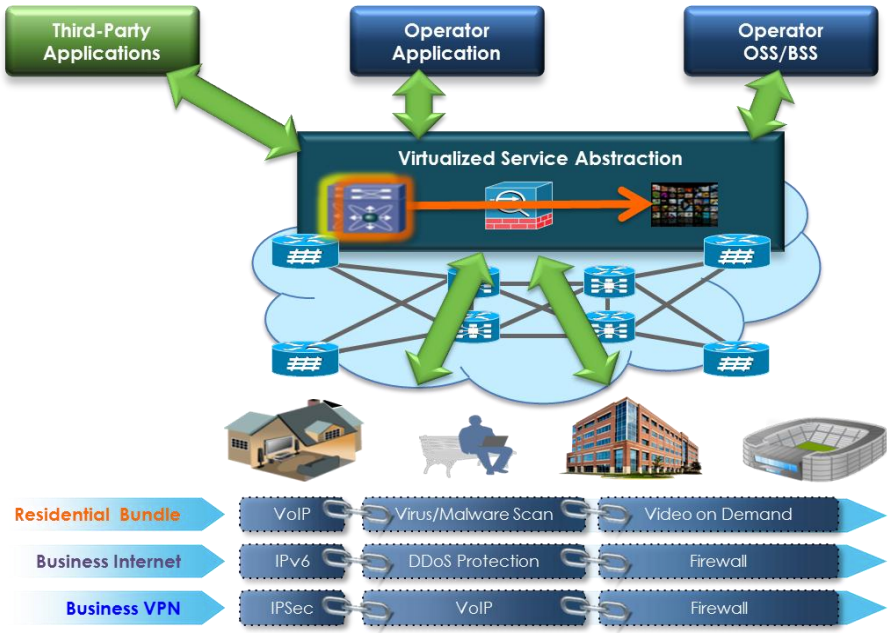
Using Cisco ONE to Support SDN-Enabled Service Innovation

The Cisco Open Network Environment (ONE) is a customizable software framework of use-case-based modular technologies that service providers can use to harness the untapped value of their intelligent networks and rapidly create and monetized new services while simplifying operations. Cisco ONE encompasses multiple SDN approaches for network programmability, a bidirectional feedback loop between network and applications, and innovative orchestration and automation capabilities that may be applied to deliver a broad range of business solutions across a virtualized cloud, video, mobile and transport service delivery infrastructure.

Cisco ONE: Enabling Elastic Services Creation and Delivery

Faster and more granular adjustment of network resources in response to shifting business requirements is paramount to optimal monetization of new services. In the elastic service creation use case (**Figure 5**), Cisco ONE employs NFV combined with standards-based service chaining and cross-domain service orchestration to automate the creation of customized consumer or business service delivery bundles for faster monetization. In this scenario, the network complexity is hidden from higher-level applications, and overall business agility is increased.

Figure 5: Elastic Services Creation & Delivery



Source: Cisco

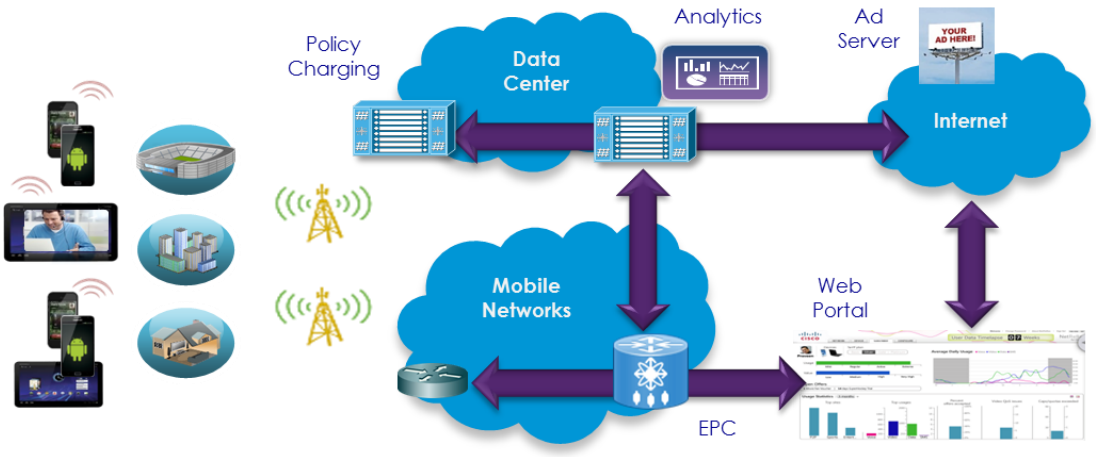
A key aspect of this solution is the ability to employ controllers and analytics engines to monitor the utilization of virtual machine and network resources and dynamically adapt them based on service demands. Customers can request any combination of available services through an open Web portal. The service

request is handled by Prime Fulfillment application to register and create a cross-domain service workflow. It provisions both the network and data center resources using an open Representational State Transfer (REST) interface. Once the customized service bundle configuration is created, it may be deployed into multiple data center locations. Cisco Quantum WAN orchestration software provides virtualized multilayer path computation in concert with embedded Cisco nLight control plane software to guide traffic engineering and ensures that IP and optical network service resources are available for optimal application performance across multiple data centers. Traffic and service demands are automatically correlated with the current traffic load and performance to determine and adapt optimal paths and data center resources for each application.

Cisco ONE: User Analytics Enables Dynamic Pricing and Policies

A significant amount of valuable and currently untapped information is available in the network, and the Cisco Quantum suite of analytics, policy, charging and orchestration software now uses this information to enable service providers to dynamically create differentiating service offerings. The correlation of data collected about the user's behavior, real-time events analysis and the subscriber's profile can be used for a broad variety of targeted service offerings. With User Analytics, virtualized analytics engines interpret and determine the user's intent and monitor customer traffic (**Figure 6**).

Figure 6: User Analytics Enables Dynamic Pricing & Policy



Source: Cisco

Based on the real-time state of the network and the user's profile and service, new offers, advertising or pricing options are created and provided to a mobile Web portal via an API gateway. Once a new service offer is accepted, a consistent user policy, charging and security profile is dynamically applied for that user, enabling the network to respond to these application requests and automatically adapt the user profiles via the Cisco ASR 5000 Series platform independent of the access technology. Cisco ONE enables service providers to dynamically transform their infrastructure and service delivery models to efficiently use their network and operational resources in line with their revenue growth, while providing a means to accelerate the introduction of new revenue-generating services.

Vendor Perspectives: Skyfire

Skyfire Uses the Cloud to Help CSPs Deliver Innovative Software-Defined Video Optimization Services Today

The move away from proprietary inline appliance hardware and into a software-defined world is not merely inevitable and already underway; it intuitively and ultimately *makes sense* for every link in the network chain, up to and including the consumer. "SDN" may still be a term looking for full resonance and definition, but Skyfire believes that SDN is anything that's dynamically configurable in the network in real time and allows for flexible, fast decision-making and intelligent routing via software. Innovation in network virtualization is disrupting the hidebound, limited networking strategies of the past, and while every major industry shift takes time to fully play itself out, there are steps that mobile network operators can take right now to start realizing the benefits of the SDN promise.

Today, it's difficult to leap directly to virtualizing the entire network, including Evolved Packet Core (EPC) and Gi LAN and all of its functions, yet a considered process can allow for step-by-step, lower risk adoption. One lower-stakes, higher-reward area in which to begin the shift is to look for a cloud-based application that robustly and flexibly delivers game-changing performance and outsized network benefits. Service providers can prove the viability of individual virtualized functions starting now, such as the traditional in-network function of data and media optimization and traffic shaping.

Mobile video and data optimization is a top concern of service providers, given the rapid and unprecedented growth of pipe-clogging video traffic on 3G and even 4G Long Term Evolution (LTE) networks. Cisco's latest Visual Networking Index predicts a 75 percent CAGR for mobile video, and that it will be a whopping 66 percent of all data traffic on global mobile networks by 2017. A flexible, light-weight, cloud-based approach to compressing and optimizing video on the fly is inherently suited for an SDN approach, given video traffic unpredictability and the need to rapidly scale to support event-based spikes in usage – something that can't effectively be done in the legacy hardware environment that SDN is replacing.

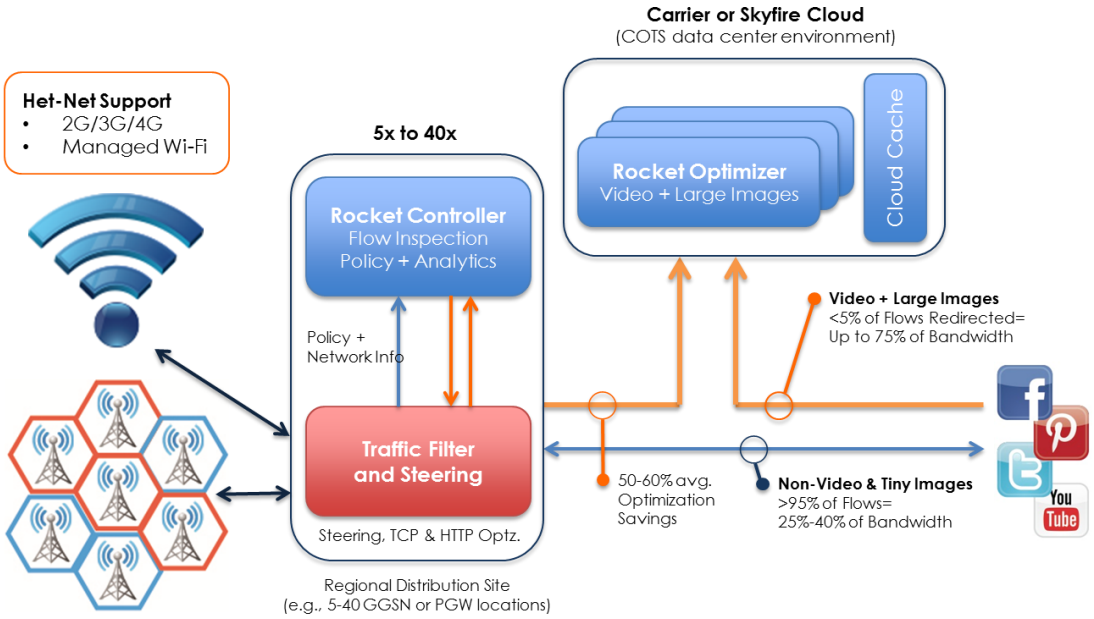
Skyfire's mobile video optimization solution, Rocket Optimizer, is SDN and NFV-ready *today*, and makes for a robust and compelling use case for operators looking for immediate cost, flexibility and user experience benefits from a virtual-ized cloud. Video and multimedia optimization in the cloud is possible when intelligent routing and steering partners – such as F5 Networks, Cisco Systems, A10 Networks, Procera Networks and ConteXtream – are already present in the network, and Skyfire works closely with all of these and more to deliver a 60 percent boost in bandwidth capacity across all device types.

For optimization, Skyfire makes use of SDN's programmable third-party routers to identify and route large, network-clogging video, streaming audio and large image traffic to the cloud for optimization and successful delivery to the end user in a matter of milliseconds. The company's Rocket Optimizer solution is tailor-made for the new flexible, configurable, hyper-network-aware and quality of experience (QoE)-centric SDN model, and it can be quickly deployed without the expense and the complexity of a legacy inline appliance implementation.

A significant differentiator that arises from this cloud-based, SDN-friendly approach is Rocket Optimizer's ability to measure, quantify and mitigate congestion on a *per-user, per-session* level, in real time, without the need for expensive hardware or

RAN probes. This allows a poor user experience to be overcome by means of video compression in the cloud, even when a given user is experiencing poor video quality from behind a wall or at the edge of an otherwise uncongested cell. Skyfire Experience Assurance optimizes the affected subscriber's video traffic by allowing as many bytes to be delivered to their device as quickly as possible *without* allowing a slow start time or buffering. Metrics such as these can be dynamically configured by the operator, and can be deployed on a per-cell, per-region or network-wide basis via the Rocket Optimizer dashboard.

Figure 7: Skyfire's Rocket Optimizer



Source: Skyfire

The combination of intelligent steering with the cloud also makes network capacity expansion extremely dynamic and quite painless in an SDN world. In traditional hardware-based architectures, capacity must be painstakingly expanded in anywhere to 5 to 40 network nodes, a lengthy "trucks and forklifts" approach that is expensive, and often one or more steps behind end users' data consumption patterns. By contrast, Skyfire's SDN-friendly architecture focuses in a mere 1-3 distributed data centers, and capacity can be elastically expanded within mere minutes, to either a carrier or a public cloud. This virtualized platform is compatible with carrier cloud initiatives and gives operators a robust, customer-friendly tool to handle planned or unplanned spikes in network traffic.

For mobile operators that are unsure of a path forward into the brave new world of SDN, but are looking for improved user experience, flexibility and decided cost reduction *today*, Skyfire's SDN-ready network solutions help clear the path to a more virtualized, software-based networking tomorrow.

Conclusion

CSPs face numerous service creation and delivery challenges because of the static, inflexible nature of their networks. As software-driven service innovation accelerates in the new digital services economy, it is putting increasing pressure on CSP networks and revenue streams. As a result, CSPs urgently need to find new ways of driving value out of their network investments by making their networks and services more relevant to application developers, other service providers and their users.

If CSPs are to remain competitive in today's fast-moving market, they will need to match the pace of innovation in the network with the speed of digital services invention. This is a difficult task given their current network environments. SDN – a software-driven approach to engineering and operating the network – is emerging as a promising foundation for a new era of CSP service innovation.

There are different ways of defining and implementing an SDN, but whichever approach is taken, the principles and objectives are similar. From a service innovation perspective, SDN is about abstracting and/or separating out hardware-based network functions in software. This increases the "programmability" of the network so that it can participate more fully in new, revenue-generating service use cases and support the agile composition of tailored services through concepts such as service reuse and service chaining.

In addition, SDN advocates a common management layer with a global view of the network that supports bidirectional communication with applications and a single set of interfaces for the rapid onboarding of new services. Once the network is opened up programmatically, a new developer ecosystem, that uses the network as a platform for innovation, can flourish.

Some SDN-enabled services are already being tested and implemented today; others show promise for the future but are still some way off. This white paper has illustrated several ways in which different approaches to SDN can and will enable service innovation in different network domains. Network owners that embrace SDN will have powerful constructs at their disposal to create new sources of revenue, not only using in-house development resources but also in partnership with enterprises, other service providers and independent software vendors.

By transforming their networks into infinitely malleable software and marrying that software with the cost-efficiency potential of the cloud through NFV, network owners have their best opportunity yet to participate fully in the digital services economy – not as bit pipe providers, but as the service innovators of tomorrow.