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CloudNFV™ unites the best of Cloud Computing, SDN and NFV

CloudNFV™

Taking NFV to the Cloud

An open platform for implementing Network Functions Virtualization (NFV) based on cloud computing and Software Defined Networking (SDN) technologies in a multi-vendor environment

We have a network today - the Internet - that spans the globe and has even extended into space. There are challenges in making all of the roles of this enormous collective undertaking profitable enough to guarantee full participation, and there are a lot of "revolutions" that have promised to help—the cloud, software-defined networking (SDN), and most recently, network functions virtualization (NFV). There are many things we don't know yet about these new concepts, but one thing we do know is that **they can't make the network of today any less pervasive, useful or powerful** than it is now. Progress means moving up, not falling back.

Network functions virtualization is potentially the unifying revolution of the three, the thing that combines the cost management initiatives needed by operators, the revenue opportunities needed by everyone in the services value chain, and the experiences that will dazzle our grandchildren even more than our current experiences have dazzled us.

Hosting network functions in the cloud is a step toward unifying the network and information technology forever, creating a seamless mesh of technical elements that support every conversation, every transaction, every experience. All we have to do is take the opportunity that NFV presents us and go forward with it, to expand from managing costs to creating profitable experiences. The cloud shows us how to go beyond NFV, how to take the first step toward our dazzling goal.

> To virtualize anything effectively, we have to virtualize everything from resources to services to functions… even to the users themselves. That's the big step because infinite flexibility is only a short distance from chaos.

One step doesn't climb all the way to the future, though. NFV is another example of how the most general concept of virtualization – the transformation of abstractions into realizations – can change everything about technology. If we are to get to that utopian cloud of tomorrow, we have to embrace that definition of "virtualization," not just fill in the stress cracks virtualization creates. To virtualize anything effectively, we have to virtualize everything

Founding members of the CloudNFV initiative include:

- **6WIND**
- **CIMI Corporation**
- **Dell**
- **EnterpriseWeb**
- **Overture Networks**
- **Qosmos**

Click on a company name above to view a summary of their participation in CloudNFV

from resources to services to functions… even to the users themselves. That's the big step because infinite flexibility is only a short distance from chaos.

CloudNFV is aimed at taking **both steps**. You'd never believe us if we said that we had the final answer to the unity of cloud, SDN and NFV. We're not saying that. We're not saying that we have the vision of a future where "everything is virtual" down pat either. We're staying that we've tackled both problems head-on. What we have set out to do is to create a framework that demonstrates that such unity is possible and that it can be made profitable.

Like the Internet, CloudNFV is open. It's not a company that's going to sell itself for a big payday or a forum that's going to charge for membership. It is an architecture supported by an open partnership. Everyone is welcome, and while we obviously can't speak personally with everyone who wants to know more about our activity, we're committed to communicating with as many as we can, using every means available. This document is where we start.

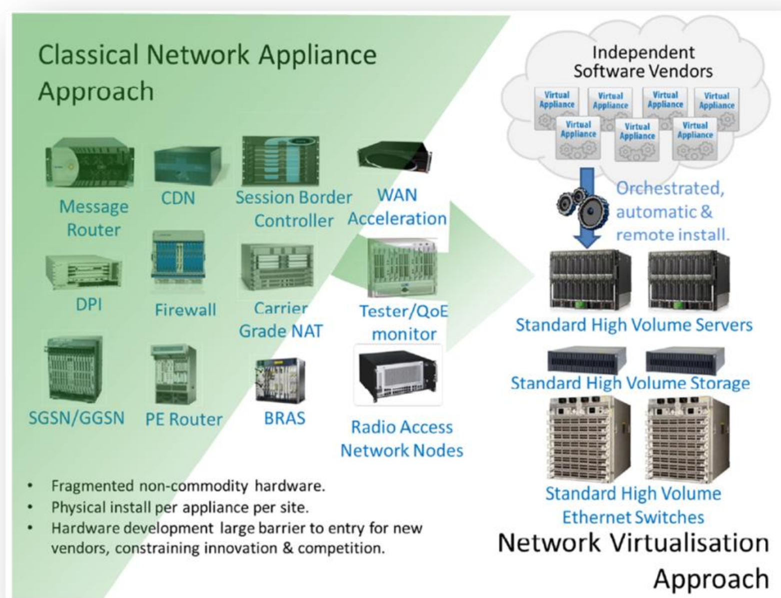
To See Through All Eyes

There are a lot of ways of looking at Network Functions Virtualization.

- It might be aimed at reducing costs or at raising revenues.
- It solves a network problem or builds toward a cloud future.
- It is about deployment of functions or about consistency and economy of operations.

Which is it? All of the above. This is the age of virtualization.

You don't get staked to a single perspective, you create an architecture that sees everything – sees through all eyes. That's what we've set out to do, but to understand how and why, we have to start somewhere. The right place is the model established by the formal ETSI Industry Specification Group on Network Functions Virtualization. We show that model in Figure 1.



Source: "Network Functions Virtualization: An Introduction, Enablers, Benefits, Challenges, & Call for Action", ETSI NFV ISG

Figure 1. The Foundational Goal of Network Functions Virtualization

Through ETSI NFV eyes, this is about moving features from high-cost to low-cost infrastructure. Functionality, now resident in specialized appliances, is extracted in some way and replicated in virtual form by an independent software vendor or the appliance vendor. When services are needed, these components are assembled (or orchestrated) and deployed on servers. The NFV plan is to support everything from bare metal to an architected cloud as a hosting platform. Once deployed, they are managed so as to create as good of a service experience as the original devices would have created.

OK, fine, but let's look at this through our carrier regulatory attorney's eyes.

Did you put your virtual functions in places that regulations might inhibit? Are you exposing users to content regulation or lawful intercept issues? Clearly, we need some policies in place to guide where virtual functions are deployed and how they're connected. It's not just a matter of finding a technically suitable server. Deployment is complicated.

Look now through the eyes of the vice president of operations.

What happens if the server hosting the function fails? Do I "reroute" through another virtual function I created on standby? Do I spin up another VM and load another copy? How do I reconnect all this? What happens if a portion of the local electric grid failed, and my backup is in the same substation zone as my primary? We need more policies, because operations and management is complicated.

All of this complexity can add up. We know that virtual routing works and that it can save on CapEx. But, let's look at this through another set of eyes, that of a carrier CFO.

The NFV plan is to support everything from bare metal to an architected cloud as a hosting platform. Once deployed, they are managed so as to create as good of a service experience as the original devices would have created.

Will the capital cost savings created by moving to virtual functions hosted on servers be eradicated by more complex operating processes as we scale out to more virtualization? How do we even manage this new virtual stuff? Where did we put that function anyway and how do we know how it's behaving? Even applying all of those policies that we just mentioned could be costly enough to jeopardize capital savings.

Our CFO eyes would also see the problem with investing to cut costs – in many ways, that's a contradiction in terms at best. Why not try to get new revenue? A. whole industry has grown up riding on "Internet dialtone" after all, and operators should be able to not only compete, but win in such a business model—if they have the right tools. Most of them are already committed to investment in the cloud, so why not try to harmonize that cloud investment and a new network architecture and support revenue gains as much as manage costs?

It's time for another set of eyes here, that of the high-level architect.

When such a person looks at Network Functions Virtualization, they see what Figure 2 shows—a trio of critical elements. We have the "network functions" that represent the logic to be deployed and assembled into services; the "functions virtualization" that represents the logic that deploys and connects the virtual functions; and the "operationalization" – the logic that keeps everything running and does the billing and business functions.

This is the NFV ecosystem at the highest level. An ecosystem that is defined by the ISG's work, but that has to be implemented as a software project to make this happen.

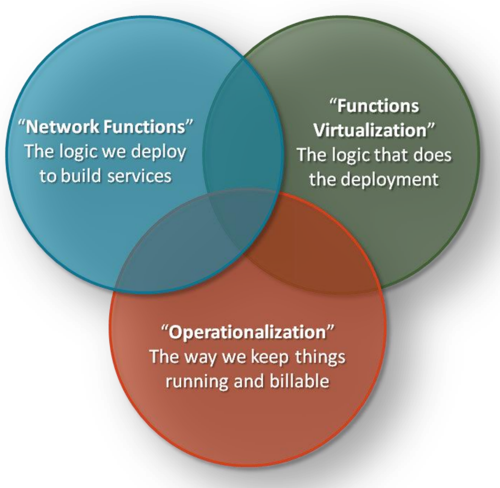


Figure 2. The Three Pillars of NFV

Our high-level architect would say, without hesitation, that what's needed is a running prototype of NFV, something that could test the basic assumptions and perhaps even test different approaches. This architecture should also integrate with SDN and the cloud, our other two revolutions.

At the April 2013 NFV meeting in Santa Clara, a group of six companies agreed to work toward building such a prototype as an open platform to validate and explore NFV issues and assumptions. We called that platform **CloudNFV** because it was architected – from its inception – to make network functions into cloud components.

With CloudNFV there's a simple goal – make every application that can run in the cloud into a potential virtual function. Cloud computing and NFV are one.

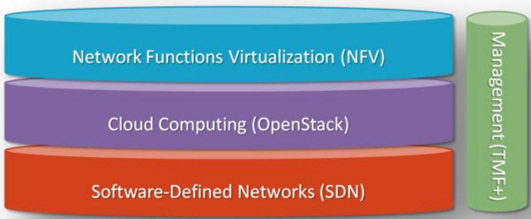


Figure 3. CloudNFV is a Stack of Technology Revolutions

We all saw CloudNFV as it's depicted in Figure 3–a stack of futuristic technologies combined to create a new network model. NFV principles from the ETSI ISG are translated into hosted functions using cloud computing principles—OpenStack to be specific. With CloudNFV there's a simple goal –make every application that can run in the cloud into a potential virtual function.

Cloud computing and NFV are one.

So are CloudNFV and SDN, CloudNFV and OSS/BSS.

The network connections between functions and with users are created using SDN. Management is accomplished through a data/resource model structured according to TMF rules but optimized for virtualization and the cloud. We took this approach deliberately to create a harmony of revolutions – to build the greatest benefit case while gaining the most in terms of economies of scale and operations.

CloudNFV answers all the questions we posed above in what we think is always the best way to address complex things—through simplification. The basic CloudNFV architecture, shown in Figure 4, does everything that the ETSI model currently defines. And, it does it through a combination of an abstract data model, optimized cloud deployment of network functions, and the best hardware/software platform available to maximize reliability, availability, performance, and management/operations.

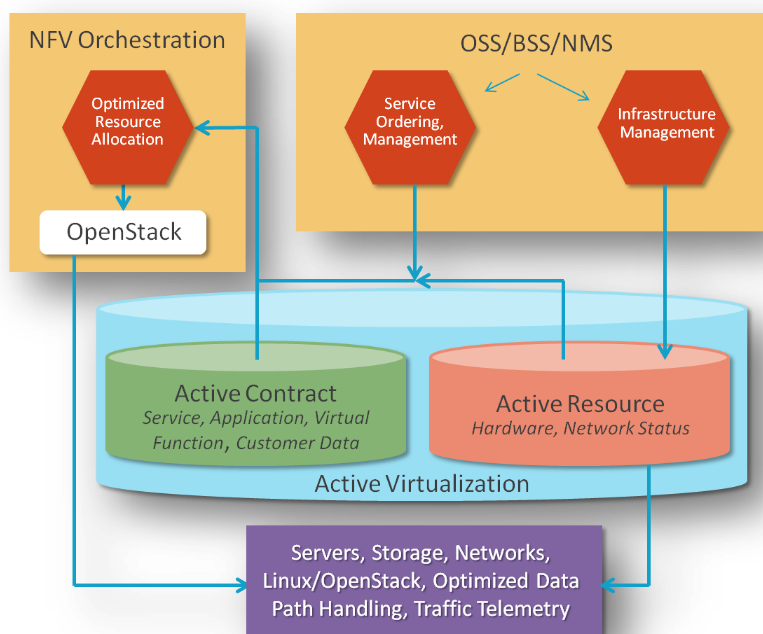


Figure 4. The CloudNFV Architecture

Browsing Through CloudNFV

If you follow along on Figure 4 for a moment, we can show you the way CloudNFV works.

Every aspect of services, functions, and resources is represented in a universal, agile, data model we call "**Active Virtualization**."

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More on that later, but let's start by saying that in the **Active Contract** portion of our repository, we have a series of Service Templates that represent structures of network functionality that can be ordered. Think of them as abstract maps—cookie-cutter frameworks that stamp out the service when somebody orders it. When that happens, the order process picks the correct template and fills in any variable parameters (service locations, QoS, whatever), creating a **Service Contract**. It's like an order for a bicycle. You specified the variables, like color and seat and trim, but all the rest of the process is standard. So far, this process is pretty much how service ordering works with real networks.

When an order is complete, we find that some of that order requires virtual functions to be deployed, and that component of the order is then dispatched to the NFV process called "Orchestration." Here, we use policy rules and resource status from **Active Resource** to pick the best spot to put all these virtual functions, and also how to connect them using virtual networking. We call the combination of the where-to-host and how-to-connect instructions a **manifest**. This manifest is given to OpenStack, which uses its Nova compute APIs and Neutron networking APIs, to create the NFV component of the service on real cloud resources using real network connectivity to link its pieces and link the whole service to the user.

When the virtual functions are deployed and connected, the resources all report their status and traffic to Active Resource and management processes running against Active Resource let you either reflect the result of your deployment as a bunch of virtual devices with familiar MIBS that support current management systems, or create your own completely new and streamlined management processes.

Whichever route you pick, your virtual management state is derived from the real status of real hosts and real networks. We call these "derived operations," in fact, and we have structured the data model of Active Contract to reflect the TMF SID (GB922) description of Services, but also to reflect how applications really deploy in the cloud. That's what makes real-time virtualization-based management possible.

So there you have it, at a high level. CloudNFV is about a harmony of revolutions, a harmony of standards, a harmony of vision. It isn't a new standard. It's a fusion of the standards that we all believe are driving the industry. It's not limited to NFV. It creates a framework to deploy legacy services based on legacy devices or to deploy software-as-a-service in cloud computing. It isn't a different approach to NFV, it's an optimized approach to the requirements that the ETSI ISG are creating. All of us are members of the ISG, and everyone who wants to integrate with us in the future will have to be a member to prove their commitment. We're also coordinating our activity with the TMF because we believe the TMF service framework is critical to integrating CloudNFV into effective operations practices, particularly as we transition between real and virtual devices.

CloudNFV isn't a product. It's proof that NFV can be implemented as an open concept, instead of a proprietary monolith.

CloudNFV is about a harmony of revolutions, a harmony of standards, a harmony of vision. It isn't a new standard. It's a fusion of the standards that we all believe are driving the industry. It's not limited to NFV. It creates a framework to deploy legacy services based on legacy devices or to deploy software-as-a-service in cloud computing.

Yes, this is a proof of concept, but it's a proof of a very broad concept. We invite you to join us—no fees, no pressures, just cooperation to advance the three critical concepts of cloud, SDN, and NFV as a single and open effort.

Finally, it’s not a point solution, but an element in a global grid. CloudNFV can run in any – and **every** – carrier data center or any OpenStack-compatible, optimized, commercial off-the-shelf server and create a cohesive global service framework. It can also federate with other compliant NFV platforms and even with cloud computing. Yes, this is a proof of concept, but it’s a proof of a very broad concept.

Finally, and foremost, CloudNFV is open to broad participation. We’ve created interface points that align with the ISG’s architecture, but we’ve also provided a mechanism for customization of management and infrastructure integration that goes beyond current ISG work. Subject to resource availability and approval of an integration plan, we’re happy to work with other ISG members to create an even broader platform, both geographically and technologically. We invite you to join us—no fees, no pressures, just cooperation to advance the three critical concepts of cloud, SDN, and NFV as a single and open effort.

Hungry for More?

If this provides you enough of an understanding of CloudNFV, you’re welcome to stop here. If you’d like a little more detail, we’ll have to jump off our Figure 4 in two directions: one to show how we assemble virtual functions into services and the other to show how our pieces connect with each other, and with future integration partners in the project.

If we dig just a bit deeper into Figure 4, we can demonstrate our vision of contract-driven management. Active Contract records the resource commitments associated with a given set of virtual functions. When we want to manage an NFV-based service, we do so by integrating the resource state from Active Resource with the resource commitments made in Active Contract. We call this “derived operations” because in a virtual world there are no real devices and so there are no meaningful MIBs.

In our Active Contract service template, we identify a “Management Visualizer” at every level of a service – retail down to individual virtual functions. This Visualizer draws information from Active Resource to frame the management view appropriate to that point in the structure (at the service level, you might have a red/yellow/green light dashboard). When the service is deployed, the Management Visualizer can see from the Contract what resources are used and it knows how to derive the right management view.

All of this is based on a “Service” model taken from the TMF SID GB922 framework we referenced earlier, but that we’ve adapted for NFV use as shown in Figure 5 Starting at the bottom, the NFV ISG defines the individual, hostable, elements of a service as “Virtual

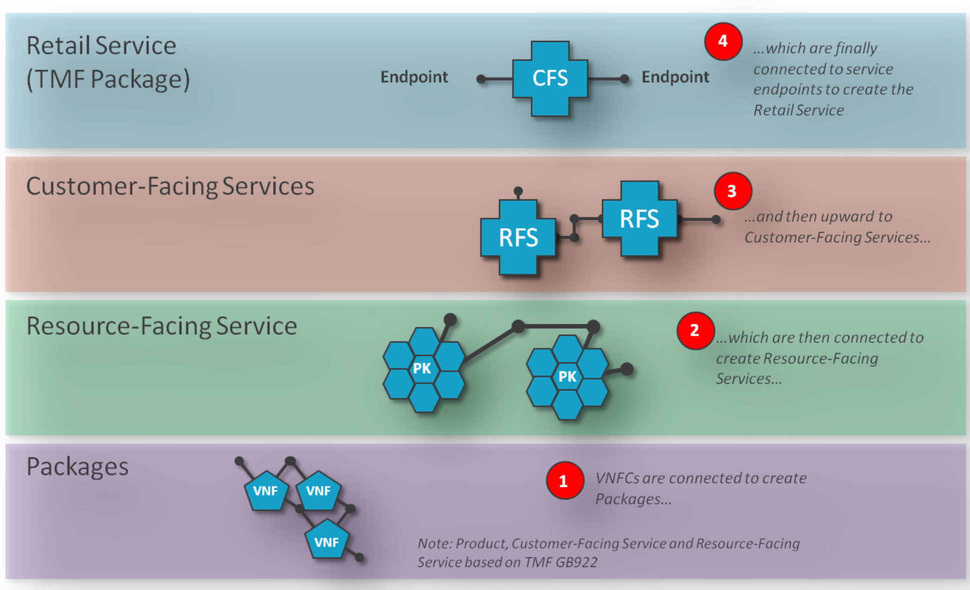


Figure 5. CloudNFV Service Hierarchy and the TMF Connection

Network Function Components" or VNFCs. Each of these has an associated descriptor (a VNFD) to define the rules of hosting and connecting for that particular function. When a service is created from virtual functions, it's built upward from these VNFCs as the figure shows. Our first "assembly" of VNFCs is what we call a **package**, a term taken from cloud and Linux deployment to describe a collection of application components that are deployed as a unit.

VNFCs have interfaces, but packages have instructions on how those interfaces are to be connected, both among the VNFCs in the package and with external structures and users. Package descriptions define how these connections are made thereby defining the interfaces that packages expose up the line. Right now, what we call packages i the high end of what the NFV ISG defines.

To get the rest of the way to services, we've jumped at our next level to TMF GB922 terminology. A **Resource-Facing Service** is a collection of one or more packages that map to specific current TMF or TMF-linked OSS/BSS processes. RFSs, like packages, treat what's in them as a collection of exposed interfaces to be connected. To CloudNFV, the process of connecting those interfaces is symmetrical from packages all the way to the retail top of the chain. RFSs can be linked with commercial terms and commercial SLAs to create **Customer-Facing Services**, and it is these services that combine to create the retail service offering that we call a **Retail Service** and that the TMF calls a "product".

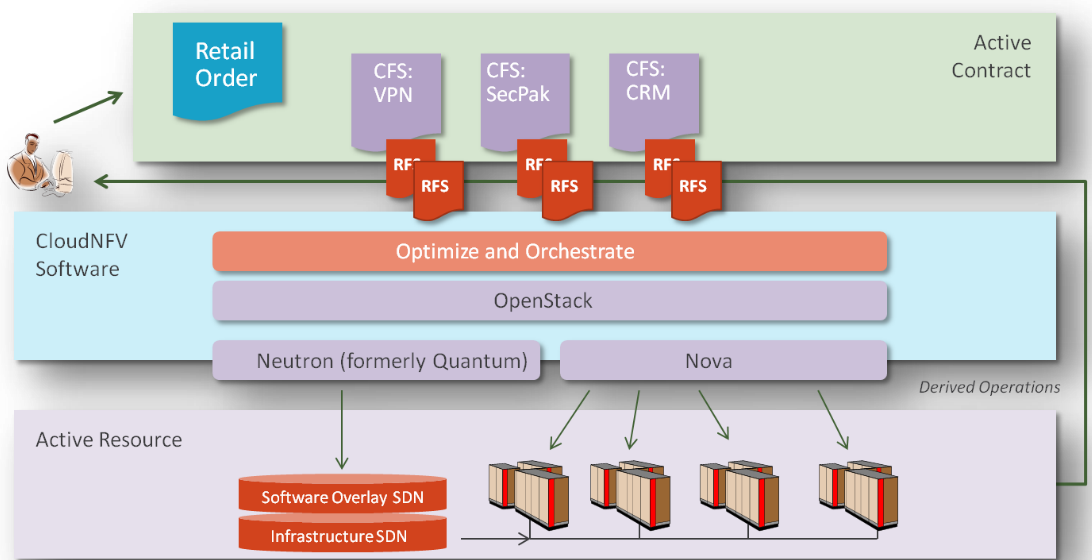


Figure 6. "Derived Operations" and Management Model

We can now express our management model more in terms of this TMF-inspired structure, and that's shown in Figure 6. When a service is created, it's built from a **Service Template** stored in Active Contract and filled in by the customer or order entry process. The template then becomes a **Service Contract** whose structure of CFSs, RFSs, packages and VNFCs matches that template. The Contract is sent to CloudNFV's Orchestration and Management process for handling, and there we do a sophisticated policy-and-resource-state analysis to determine where we need to site the VNFCs -- specifically in which VMs in the cloud they'll be hosted. We also determine how their interfaces will be connected by real services. When we have both of these, we have that **Manifest** of deployment instructions that will process through OpenStack (Nova for compute, Neutron for networking, etc.) to deploy and connect the service as though it were a componentized cloud-hosted application. The completion of package deployment means that connection process simply moves up the ladder through RFSs and CFSs until we have connected the final service end-to-end. The resource commitments, you'll recall, are stored in Active Contract as we go along.

When somebody wants to manage the Contract, they start with the Contract itself (which provides the customer context, SLA objectives and resource commitments) and use the Management Visualizers at each level of the structure to view (and potentially alter) the variables that were deemed appropriate to that particular structure. Each retail service, CFS, RFS and package can define its own management view, but there are other management options we'll get to in a bit. A Management Visualizer has instructions for both **derivation** of the variables it presents (where they come from in Active Resource and how they are aggregated into a virtual vision of status), and the **presentation** of those variables in terms of both format and API. You can have any management derivation and presentation you like – a -- just use a Management Visualizer to create it. You can also define multiple presentations of the same derivations, etc. Everything is virtual, remember?

Let's close our deeper look with an implementation-and-integration vision of CloudNFV, which we show in Figure 7. Here, we start with two collections of "stuff" – the collection of service information, virtual function information,

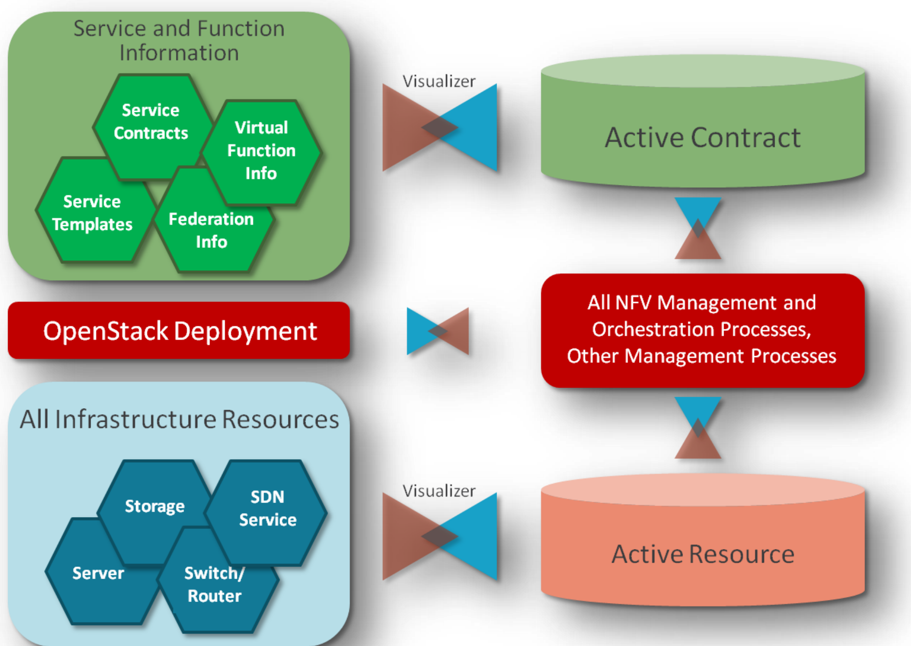


Figure 7. An Implementation Model of CloudNFV

implementation policies and the collection of service infrastructure/resources. These two collections are connected to CloudNFV through Visualizers (as you likely guessed) and form Active Contract and Active Resources, which are themselves simply "visualizations" of our grand collection of information and knowledge that we call "Active Virtualization."

All of CloudNFV's processes and functions are driven from Active Contract, Active Resource, or both, gaining their information and functionality needs through Visualizers that can build data models or process models equally well. We optimize deployment using Visualizer data. We pass Manifests to Orchestration through a Visualizer and when we manage something (real resources, virtual resources, services, or just convenient and arbitrary collections of things), we do so through Visualizers. If you want to integrate with CloudNFV, you can bet that you'll be using Visualizers to do it, too.

So who does all of this? Our next step is to introduce the companies who have implemented the CloudNFV vision. First, we'll take a look at Figure 8in terms of who does what, and then we'll let each of the companies frame their participation in their own way.

The CloudNFV Team

CloudNFV is a cooperative project. Involved companies are listed in alphabetical order below and illustrated in Figure 8.

6WIND provides high-performance data plane software that accelerates the performance of NFV deployments. As the number one supplier of high-performance networking software for telecom infrastructure implemented today on physical platforms, 6WIND is well-positioned to also solve the data plane performance challenges for virtualized solutions. Within CloudNFV, the 6WINDGate™ software is used in two places. First, it accelerates the Open vSwitch (OVS) that switches network traffic to the Virtual Networking Functions (VNFs). Second, it accelerates the VNFs themselves.

CIMI Corporation is the architect of the CloudNFV concept, the source of the high-level design and the assembler of the team. Tom Nolle, president of CIMI, is a well-known industry analyst, software architect and author.

Dell Inc. is the provider of the server systems, the data center SDN switches, the Active Fabric Manager and OpenStack Neutron plugin, and the lab space used for testing and demonstration. Data center hardware reliability is critical to NFV. Dell has also been the systems integrator for CloudNFV and they have coordinated the hosting of virtual functions for the demo.

EnterpriseWeb is the provider of “Active Virtualization” the encompassing data/logic model that binds services and resources and provides the optimization and management framework for CloudNFV. Most of our integration with new partners will come about through connections EnterpriseWeb supports. They also acted as the Implementation Coordinator for the project.

Overture Networks is the provider of the orchestration logic for NFV, which takes an optimized “manifest” of deployment and connectivity requirements and realizes the actual instantiation via OpenStack APIs. Overture is the key to multi-vendor network support (via Neutron) within CloudNFV and they also provided the metro/Carrier Ethernet switching for inter-data-center connectivity.

Qosmos plays two critical roles in CloudNFV. First, their traffic probes provide us with monitoring of the critical flows that let us optimize network utilization and performance. Second, their “DPI-as-a-Service” capability is used in our demonstration to illustrate the NFV concept of Service Chaining.

In addition to these six founding firms, we're pleased with the support provided by **Metaswitch Networks**, whose open-source IMS "Project Clearwater" was the best cloud-ready virtual function resource we could find. Clearwater already enjoys operator support and is in trial in various regions of the world, and they've been very helpful in acting as a test-bed in integrating virtual functions into an operating demonstration.

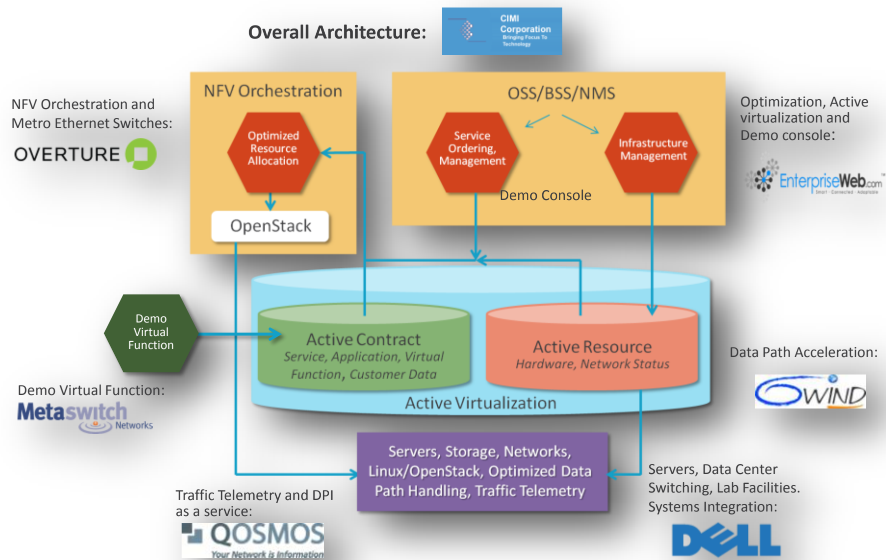


Figure 8. Meet the CloudNFV Team!

If you're interested in learning more about each of the partners, we're offering a short description of each company and their role, provided by the firms themselves, as attachments at the end of this document.

We've Only Just Begun

CloudNFV has a pretty intense mission, and even though we've architected to simplify development and deployment, we're sure you understand that this has been no small undertaking. Even documenting CloudNFV isn't trivial, and so we're forced to develop documents as we progress in our testing through the summer and fall of 2013. We ask everyone to be patient as we prepare more material, and also that those who want to work with us in some way go to our website and check the current state of the project and the avenues for participation. The Documentation tab includes a paper describing the various programs for participating in CloudNFV and the way we're organizing and running them. We ask everyone to recognize that we simply cannot do one-on-one discussions with everyone interested in learning about us or working with us. Please follow the guidelines and we'll do our best.

This reveal, us opening our activity to new participants, isn't the end of our process. CloudNFV will evolve as integration of new components advance its functionality. That evolution is our primary goal – a goal driven by our desire to create a framework for cloud-hosted virtual functions, applications, and experiences that's as scalable and powerful as the Internet. Will there be other frameworks? We're sure there will, and we hope that those who want to develop them will join with us, learn from our successes and mistakes, and participate in what might well be the grandest telecom experiment of all time. Join your vision, your eyes, with ours and we'll see the future.

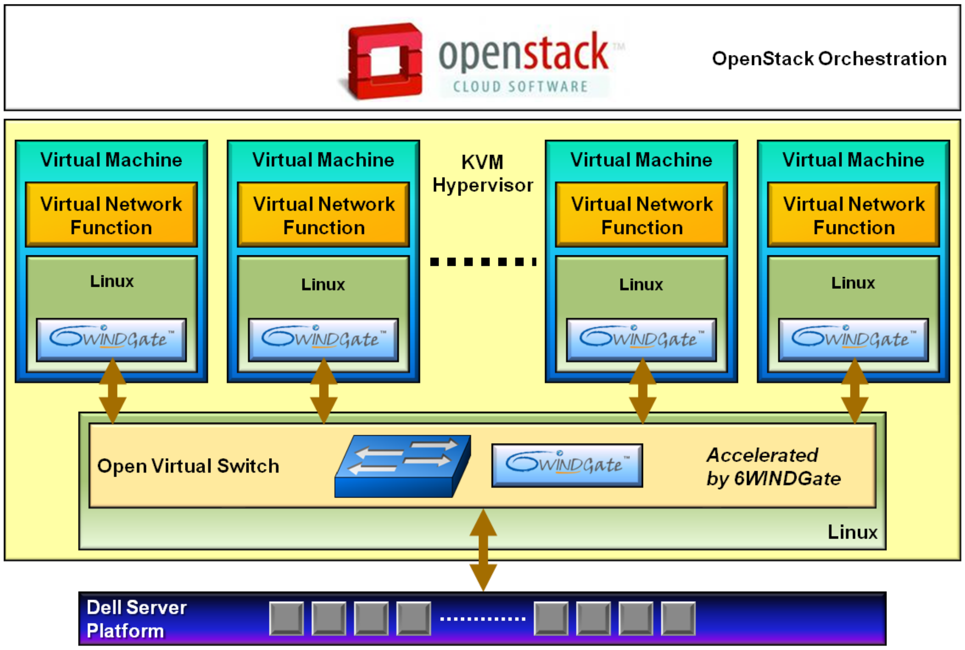
CloudNFV will evolve as integration of new components advance its functionality. That evolution is our primary goal – a goal driven by our desire to create a framework for cloud-hosted virtual functions, applications, and experiences that's as scalable and powerful as the Internet.

6WIND Summary for CloudNFV

Company Background

6WIND, a networking and telecom software company, provides high-performance data plane solutions that accelerate the performance of Virtual Network Functions and Virtual Switches. As the #1 supplier of high-performance networking software for LTE infrastructure, generally implemented today on physical platforms, 6WIND is well-positioned to solve the networking performance challenges for Virtual Network Functions in NFV.

6WIND's Software in CloudNFV



Within CloudNFV deployments, the 6WINDGate™ networking software is used in two places.

First, 6WINDGate accelerates the performance of Virtual Networking Functions (VNFs).

Thanks to its fast path data plane architecture 6WINDGate typically delivers 10x the performance of a standard Linux networking stack with no changes required to the kernel.

6WINDGate includes a comprehensive set of networking protocols (IP forwarding, routing, virtual routing, PPP, firewall, IPsec, IKE, TCP termination etc.), ensuring that all VNFs are accelerated.

6WINDGate is fully compatible with standard Linux networking APIs so the VNF applications run unmodified.

6WINDGate enables operators to achieve best-in-class cost-performance from VNFs running under KVM, such as firewalls and security gateways.

Second, 6WINDGate accelerates the Open vSwitch (OVS) that switches network traffic to the Virtual Machines (VMs) in which the VNFs are instantiated.

Typically, 6WINDGate delivers a 10x improvement in OVS switching performance, with no changes required to the OVS code itself. In many cases, this 10x increase in switching performance results in at least a 3x improvement in the number of VMs that can be instantiated per server (the VM density).

As part of improving OVS performance, 6WINDGate accelerates the secure tunneling protocols such as IPsec, GRE, VLAN etc which are required for high-bandwidth VM-to-VM traffic.

In these two environments, 6WINDGate runs within KVM, under the control of the OpenStack orchestration layer.

Whether to reduce cost, increase revenue or revitalize an entire ecosystem, Network Function Virtualization (NFV), Software Defined Networking (SDN), and open cloud computing technologies can together form a solid foundation for transforming our planet's vast communications infrastructure into the cloud age.

Dell Inc. is delighted to be a founding member and the Proof-of-Concept system integrator of the CloudNFV™ open project. CloudNFV™ was launched by a consortium of seven companies, led by CIMI Corporation, to realize the vision of NFV using standard open cloud computing and SDN technologies, and to demonstrate so in an open Proof-of-Concept phases. Dell will be hosting the PoC in its Silicon Valley lab.

Dell's vast portfolio of globally available data center infrastructure, cloud and multi-cloud management software solutions, and related services for development, integration and support help customers worldwide to quickly deliver applications, streamline the management of systems (including servers, networking, storage, NEBS compliant OEM infrastructure), expand your virtual environment, and rapidly adopt cloud-based infrastructure.

Dell is a leader in helping customers build, modernize and optimize data centers with a unique transformative approach. Our experiences in data center deployment and management, and our focus on results for customers add to the ingredients of success in realizing the vision and benefits of NFV.

We are excited being part of CloudNFV™ and the coming transformation of our customer's network infrastructure, and the positive impact we can have in enabling a new Internet.

About Dell

Dell Inc. (NASDAQ: DELL) listens to customers and delivers innovative technology and services that give them the power to do more. For more information, visit www.dell.com.

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EnterpriseWeb™ (www.enterpriseweb.com) is a lightweight and elastically-scalable application fabric that supports the orchestration, optimization and management of Virtual Network Functions for CloudNFV™.

EnterpriseWeb enables CloudNFV's **Active Virtualization** framework, which provides an extensible model for semantically relating the entities, policies, services, resources, protocols and processes that all participate in the delivery of a Virtual Network Function over diverse network and cloud hardware.

"Active" Virtualization is a critical distinction at the heart of CloudNFV. It extends well-established notions of virtualization to allow for a more loosely-coupled and dynamically adaptable architecture.

Virtualization is an abstraction or set of abstractions that conveniently 'hides' complex relationships between devices, software and services to effect a functional sub-system that can be addressed/automated collectively. As with many conveniences, there is a trade-off. For virtualization to work the model generally imposes a fixed set of rules that govern the relationships to provide a guarantee, which supports a specific utilization, but precludes many others – it's programmable, but not adaptable (rules are "baked-in"). Moreover, changes in the components or the relationships between the components can break applications – it's brittle. Traditional virtualization can create physical constraints that compromise agility.

> *We see this in the design of Web-Services and RESTful APIs, which hide their implementation details behind static interfaces. If a Service or API doesn't meet a specific need of an application, even if the new requirement represents only a minor change in the relationship of components, it nonetheless requires development of yet another discrete Service or API. This leads to library growth, which increases related maintenance costs and lowers overall development productivity – an unintended, but material consequence of the design.*

EnterpriseWeb achieves the benefits of virtualization, hide complexity to automate collections of devices, software and services, without the tight-coupling. With EnterpriseWeb the models bind to resources dynamically – they stay truly virtual. This allows the components of an orchestrated service to independently evolve. Components can be changed and even replaced, during live operations, without breaking the model. The approach supports optimization as the model can query a network for the latest and most appropriate resources. This is *Active* Virtualization.

In CloudNFV, we model services as combinations of virtual functions and network behaviors. Every service is an abstraction. When those services are ordered we create an optimized map of how the abstraction becomes real—and we then use CloudNFV's orchestration model to instantiate virtual functions, then connect those functions with each other and with users. We record the resource assignments, and we derive a continuous view of the operating state of the service and all its components from those records—drawing on our repository of resource state information collected from everywhere in the network and the cloud. Our CloudNFV partners, 6WIND, Dell, Overture Networks and Qosmos can all provide us with telemetry on service and resource conditions, and we translate these into meaningful management views.

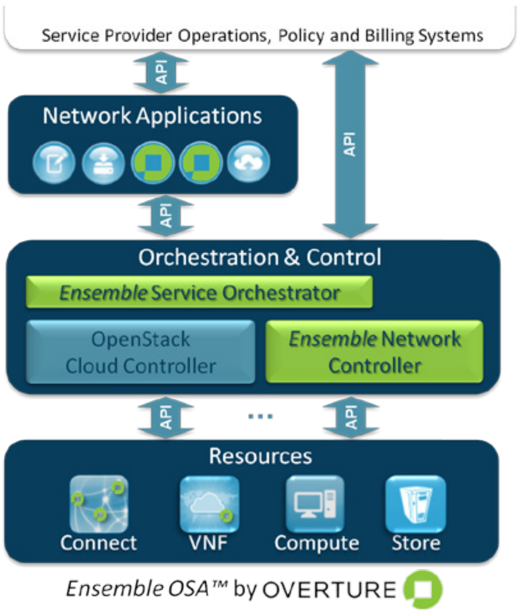
EnterpriseWeb supports the agility goals of CloudNFV and the differentiated services that will dominate carrier revenue models in the future.

OVERTURE

Overture’s Role in CloudNFV

Overture is participating in the CloudNFV project to support and advance the work of the ETSI NFV ISG. In particular, Overture is contributing its Ensemble Service Orchestrator (ESO), Ensemble Network Controller (ENC) along with the Overture 6500 and 65 metro service edge switching resources.

Overture is the preferred provider of Carrier Ethernet solutions for the metro edge. Known for innovative solutions that enable high-capacity Ethernet services over any media including fiber, copper and TDM, Overture has extended its commitment to innovation with Ensemble Open Service Architecture™ (*Ensemble OSA*™). By leveraging Overture’s Carrier Ethernet expertise and this new open architecture for software-defined services, network operators and service providers worldwide can reduce costs, maximize operational efficiencies and introduce new revenue-generating services on a scale never before possible.



NFV ORCHESTRATION:

In the context of CloudNFV, the *Ensemble* Service Orchestrator (ESO) converts an Optimizer-generated manifest describing hosting locations and connectivity into deployment commands. ESO is a high-availability, open and field extensible platform for managing the entire cycle of VNF onboarding, chaining, federation and operations to support ETSI NFV use cases such as virtual Enterprise and IP Multimedia System (IMS). ESO leverages the OpenStack™ cloud management system and the Ensemble Network Controller to commission the VNFs, physical elements and the network connectivity between them and the end users. ESO works with the Active Resources construct to optimize resources across the virtual and physical worlds.

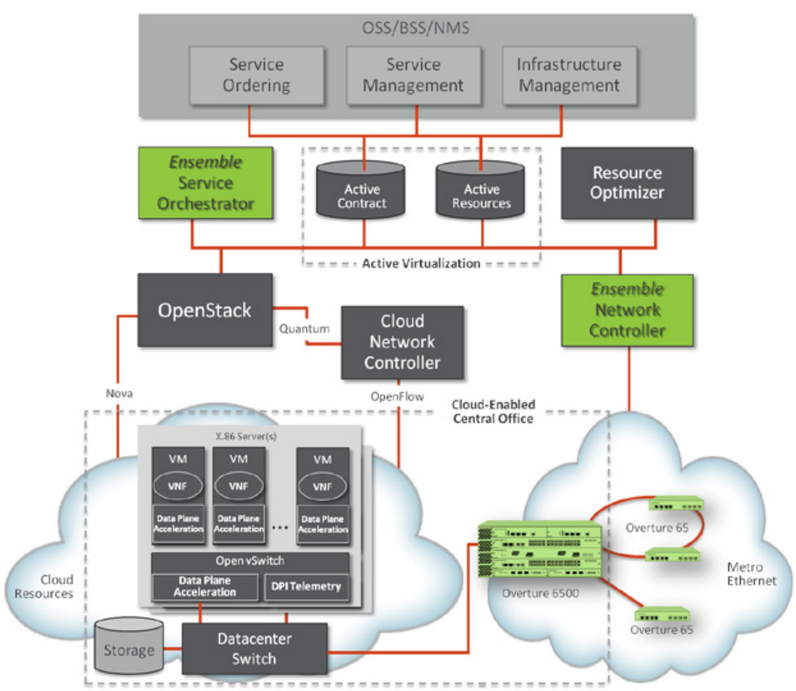


Image courtesy of CloudNFV™ Taking NFV to the Cloud ©2013

WAN NETWORK CONTROL:

In CloudNFV, the Ensemble Network Controller (ENC) serves as the WAN infrastructure SDN controller, bridging the virtual network overlay and the physical network worlds. It is a fully Metro Ethernet Forum (MEF)-compliant controller extensible to MPLS and IP networks. The ENC supports a direct interface to the ESO and will soon be available as an OpenStack Neutron (formerly Quantum) plug-in, forming the basis of the industry’s first Carrier Ethernet FCAPS controller aligned with the CloudNFV model. It automates the entire lifecycle of the metro edge network from service creation, activation to assurance. It is a high-availability system and supports the scale required to manage tens of thousands of devices at the metro edge. In the initial CloudNFV demonstration, the ENC serves as a peer to the Cloud Network controller, which together provide abstraction and interfaces into the network resources, both physical (switches) and virtual (vSwitches).

NETWORKING RESOURCES:

Overture’s innovative 6500 Carrier Ethernet Service Delivery Platform provides the WAN connectivity to the various elements in the CloudNFV ecosystem. The 6500 is used as the primary traffic steering element, steering traffic to the virtual switches and chained VNFs. The Overture 65 next generation Ethernet Access Device (EAD) forms the end customer located service demarcation point.

Overture is pleased to support the CloudNFV initiative in demonstrating the viability of a cloud-based NFV platform. Through *Ensemble OSA*, service providers can capitalize on the NFV and SDN revolutions to bring the benefits of cloud technologies and virtualization to the metro edge.

Qosmos contributes to standards through Network Intelligence and DPI NFV initiatives

Qosmos plays an active role in initiatives piloted by the Open Networking Foundation (ONF™) and ETSI Network Functions Virtualization (NFV) Industry Specification Group (ISG), contributing to emerging network standardization for DPI and Network Intelligence.

As a member of the ONF™, Qosmos participated in the elaboration of the MEC L4-L7 Requirements document which was behind the L4-L7 service requirement adopted by the Technical Architecture Working group. Qosmos continues to be an active contributor in this group.

As part of the ETSI NFV ISG, Qosmos contributed to the Software Architecture group for the use case definition of the Virtual Networking Function Component (VNFC). Qosmos' DPI engine was used as an illustration in the definition.

Qosmos is a founding participant of the CloudNFV™ open project which was launched by a consortium of companies, led by CIMI Corporation, to implement the NFV model using standard cloud computing tools and principles as described by the ONF and NFV ISG. Qosmos is delighted to be part of this initiative and to have the opportunity to demonstrate Proof-Of-Concept in the SDN & NFV deployment phases.
"Having DPI-as-a-service is a critical element in a number of service provider NFV applications and use cases such as policy-based traffic shaping and management applications" Qosmos says.
The way to provide DPI VNFC characteristics will allow the service providers to optimize the VM placement and orchestration upon the physical resources.

About Qosmos:
A pioneer in Network Intelligence based on DPI, Qosmos is the leading independent OEM provider on the market, serving more than 50 vendors worldwide. Based in Paris, Qosmos has offices in Silicon Valley, Singapore and London. For more information, please visit www.qosmos.com

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