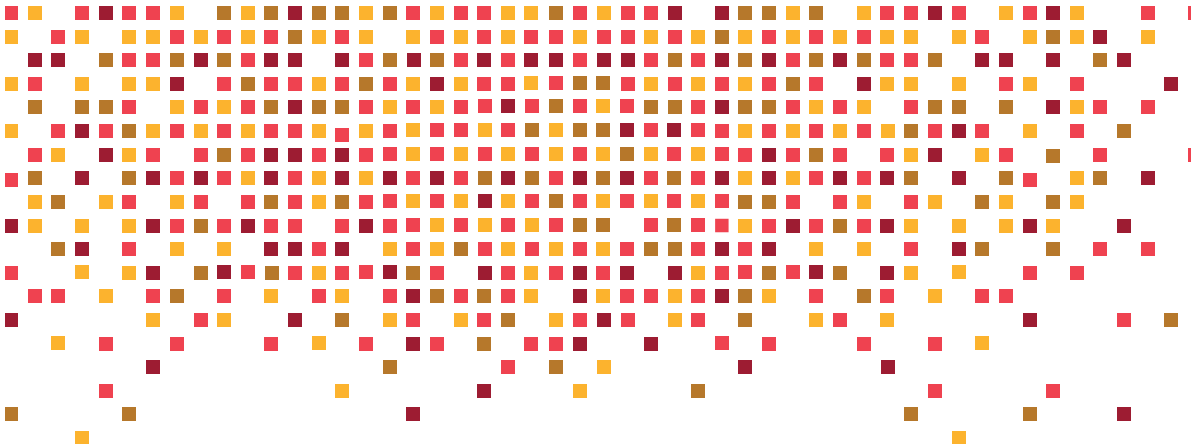


# UNCONSTRAINED DATACENTER NETWORKS FOR THE CLOUD ERA

## Abstract

The value of cloud services lies in the rapid and cost-effective instantiation of applications that can be consumed by users anywhere. Enterprises expect cloud services to increase their agility in turning up applications while simplifying their operations. For cloud services to thrive, the networks within and across datacenters must evolve to become as virtualized and readily available as the server and storage infrastructure. For the business value of cloud services to be delivered, compute and network resources must both be dynamic and instantly available.

Nuage Networks™ removes the constraints of the datacenter network through an innovative Virtualized Services Platform (VSP) that abstracts network capabilities and automates service instantiation. With the Nuage Networks Software Defined Networking solution, cloud service providers, web-scale operators and large tech enterprises can build a robust and scalable multi-tenant networking infrastructure that delivers secure virtual slices of readily consumable compute, storage and networking instantaneously across thousands of tenants and user groups.



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# UNCONSTRAINED DATACENTER NETWORKS FOR THE CLOUD ERA

Nuage Networks™ delivers programmable and automated network services to support the most demanding virtualized applications across multi-tenant infrastructures.

## Understanding the limitations of today's cloud datacenters

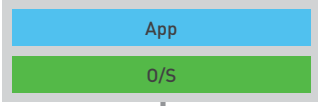
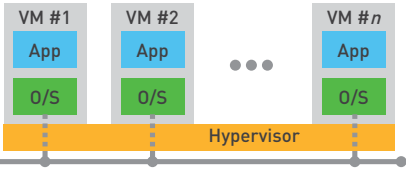
The value of cloud services lies in the rapid and cost-effective instantiation of applications that can be consumed as needed by users anywhere. With cloud services, enterprises can broadly deploy applications very quickly to meet their business needs while enjoying the benefits of simplified operations. In fact, enterprises expect the cloud to deliver the experience of a private IT infrastructure with the superior economics of a shared infrastructure.

Datacenters are at the heart of the cloud, where powerful compute and storage resources reside. The networks that interconnect them must operate in harmony to deliver cloud-based applications ever more efficiently.

The watershed event that made compute resources much more dynamically consumable was server virtualization. Server virtualization paved the way for dynamic resource sharing in servers and catalyzed the move to the cloud. This change in compute resources also triggered a profound impact on the datacenter network infrastructure.

Today, dozens of virtual machines (VMs) are easily established on a server that was once dedicated to a single environment and application. As a result, there is a huge — 40x to 100x — increase in the number of virtual network endpoints that can exist within the datacenter. Furthermore, these endpoints are dynamic in nature. As virtual machines are turned up and released, the network services that interconnect them must follow instantaneously and evolve just as dynamically. See Figure 1.

**FIGURE 1. Comparing traditional and virtualized datacenter environments**

	Physical Server	Physical Server
		
	<b>Traditional Server Environment</b>	<b>Virtualized Compute Environment</b>
<b>Number of network endpoints</b>	1	4 – 40+ VMs/Server
<b>Nature of network connections</b>	Static	Dynamic
<b>Connection longevity</b>	Months / Years	Hours / Days
<b>Connection longevity</b>	Simple	Variable

For cloud services to thrive, the networks within and across datacenters must evolve to become as virtualized and readily available as the compute infrastructure.

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This is not the case with today's datacenters. Applications running on virtual machines that come up in minutes must wait hours or days for network services to be established. The datacenter network infrastructure is cumbersome to operate, requiring multiple levels of configuration within and across operational support and change-control systems. These static, configuration-driven processes compound the delays in turning up new applications and services, diminishing customer experience while dramatically increasing operational costs.

The efficiency of the datacenter infrastructure is compromised as networking constraints limit the optimal placement and movement of workloads. Today's datacenter network is optimized within islands of connectivity, constrained by racks, clusters and datacenter walls. These factors combine to adversely affect the efficiency of servers as well as the networking infrastructure.

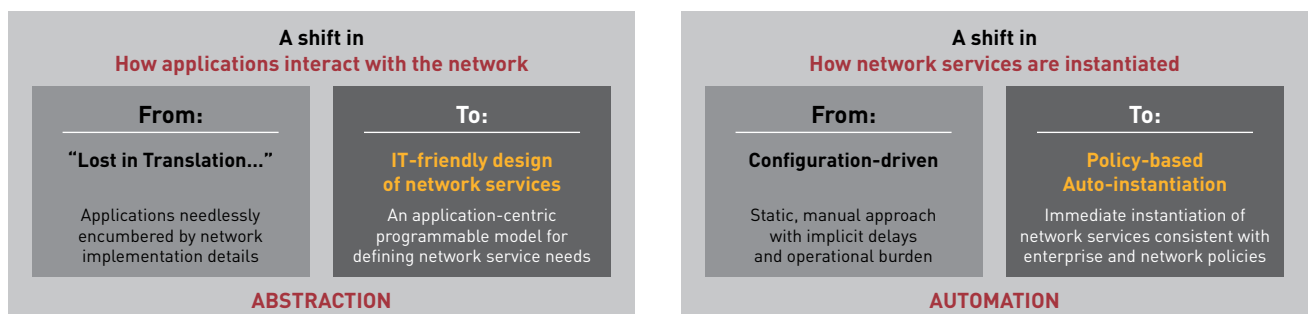
As a result, the speed and efficiency of delivering cloud-based services is being constrained by the datacenter network. As cloud services expand in scale and sophistication, these shortcomings will become increasingly apparent. The current approach has proven adequately functional despite its operational complexities and inefficiencies. But looking ahead, cloud service providers (CSPs), web-scale operators and large tech enterprises need a fundamentally new model for implementing broad-based cloud services that can thrive and reach their full potential.

**A new model for networking cloud datacenters**

Datacenter network implementations of the last decade are simply not sustainable in the cloud services era. Traditionally, static network element management utilities have been stitched together within a Manager-of-Managers (MoM) model, requiring massive integration and proving to be very complex to operate and maintain. This methodology has left datacenter operators architecturally constrained as they strive toward network automation for delivering cloud services rapidly and at scale. Outdated MoM-based models must yield to a new paradigm in order to meet the ambitions of CSPs whose success hinges on multi-tenancy, massive scale and operational efficiency.

Today, the networking services required by cloud applications are restricted on two key dimensions: the ease of their definition and the speed of their instantiation. See Figure 2.

**FIGURE 2. A new model is needed**



The definition of network services must be application-centric and simple. The networking requirements of applications should be articulated in an IT-friendly language and used to request desired network behaviors. Today there is limited programmability, resulting in an unfortunate tradeoff. Engineering of cloud applications is either encumbered by detailed network-specific parameters and information, or ignores them and treats the network as a “black box”. Neither is optimal. The first option leads to custom applications for each network type while with the second, applications lack the visibility and control needed to leverage the true capabilities of the network.

The proper abstraction of network capabilities, consistent with Software Defined Networking (SDN) principles, drives programmability of network services and increases the consumability of network resources.

The instantiation of network services must be instantaneous, aligned with the needs of applications. The network should act reflexively to establish the required connectivity within and across datacenters, and do so in a manner that is consistent with the defined policies of CSPs and their tenants. Today that process is slow, manual and error-prone, relying on work orders to establish a multitude of vendor-dependent configurations.

## The Nuage Networks approach

Nuage Networks turns the existing operational model for the datacenter network on its head, transforming network instantiation from slow to instantaneous and network services from constrained to boundary-less.

The Nuage Networks solution is grounded in three fundamental design principles:

1. Application of lessons learned from building very large IP/MPLS networks. In the “thin waist” model for scaling IP networks, intelligence is pushed to the edges. The same is in order for promoting a simple and cost-effective core datacenter network, consistent with the manner in which IP technologies have successfully scaled to date. The approach decouples network services from the infrastructure and enables parallel innovation in each domain.
2. Application of lessons learned from design of mobile networks that have been optimized to provide mobility and operational automation at massive subscriber scale. This yields a policy-driven auto-instantiation model for the datacenter network that minimizes costs and delays. The new model significantly changes the game, greatly increasing the efficiency with which cloud services can be delivered.
3. Bringing common IT language to programming the underlying network by abstracting the network capabilities into IT and business logic terminology.

In applying the first two design principles, Nuage Networks fully virtualizes and automates any datacenter network infrastructure, transforming it into a reflexive environment that instantaneously establishes the network services required to deliver cloud applications across thousands of tenants in a policy-driven manner.

In optimizing the datacenter network to be open and programmable, Nuage Networks delivers on the SDN mantra. Network services are defined from an abstraction of network resources, and implementation remains independent of the underlying server or compute virtualization environment and datacenter networking hardware.

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Intelligence is pushed to the edges; promoting a simple and cost-effective core datacenter network consistent with the manner in which IP technologies have successfully scaled to date. The approach decouples network services from the infrastructure and enables parallel innovation in each domain.

### **Simplify operations for rapid service instantiations**

In a cloud services infrastructure powered by Nuage Networks, enterprise administrators who want to conceive and deliver a new cloud application can design their network service requirements in clear, IT-friendly language.

They can define and establish enterprise access and security policies through familiar language of zones, domains, and user groups. Once network services are designed, they can be easily replicated many times. Changes in security policy or network parameters, for instance, can be applied across a multitude of users at once with the push of a single button.

The abstraction of network capabilities dramatically simplifies the definition of network services and the establishment of policies that direct network behavior.

Once network service requirements and policies are defined, connectivity must be instantiated. Today, compute and storage resources can be called up dynamically, only to encounter long delays in establishing network configurations. Nuage Networks eliminates those delays by automatically instantiating the required connectivity consistent with defined policies and network capabilities. Network services become immediately available, in sync with compute and storage resources, to ensure that applications can be delivered as rapidly as possible.

### **Address dynamic business requirements with flexible, adaptable services**

Once services are established, the datacenter network must adapt dynamically as application needs evolve. The Nuage Networks solution detects and responds to the creation and turndown of virtual machines and adapts network services automatically in accordance with established policies. It also adapts the network seamlessly as virtual machines move, independent of boundary restrictions (such as racks, clusters, and zones). Nuage Networks removes those artificial boundaries, enabling the network to respond to moves throughout and even across datacenters.

Unconstrained movement of virtual machines, accompanied by the instantaneous establishment of network connectivity, dramatically increases the flexibility and efficiency of datacenter resources. In fact, for business continuity and disaster recovery scenarios, this flexibility is a fundamental requirement.

To ensure that each tenant of the cloud infrastructure has full visibility of its slice of the network and its services, the Nuage Networks solution provides extensive analytics capabilities that enable real-time and historical usage and performance monitoring. Reports are made available consistent with CSP and tenant policies, with appropriately tiered levels of visibility and control.

### **Support massive scalability and hybrid models with a secure, open infrastructure**

With Nuage Networks, the scale and reach of datacenter network services extend as needs grow. Connectivity to VPN services ensures that enterprise locations and datacenters can be part of a seamless fabric. This is essential for delivering hybrid cloud service offerings.

In many cases, enterprises wish to keep certain databases and servers within their own private infrastructure to ensure maximum security or compliance. The Nuage Networks approach integrates that key requirement through seamless

The abstraction of network capabilities dramatically simplifies the definition of network services and the establishment of policies that direct network behavior.

interconnection with Ethernet (L2 VPN) or IP (L3 VPN) services that already interconnect enterprise sites securely. As a result, cloud bursting and hybrid cloud services are not just made possible, they are unleashed in a highly dynamic and robust manner that is an elegant extension of existing wide area data services.

The Nuage Networks solution enables CSPs to deliver these capabilities across thousands of tenants within their infrastructure, each of whom is comprised of many different groups.

Built from the ground up for the IT world of development ('Dev') and operations ('Ops'), the Nuage Networks solution frees enterprises to migrate to the most efficient models of application delivery without any compromise in security or compliance. A rich policy-based framework allows fine-grain control of access mechanisms that directly match the existing security and operational models of enterprises, and scales to meet the needs of massive multi-tenant environments.

For each tenant, service definition is customizable and template-able, with appropriate controls and relevant views of the network slice. A highly programmable analytics engine provides extended visibility of the performance of the network, with real-time alerts as well as long-term historical data processing.

Through its distributed policy-based approach, the Nuage Networks solution decouples the evolution of compute and networking technologies and allows multiple virtualization platforms to seamlessly interoperate over a single network. This significantly reduces the CSP's risks and the drawbacks of supplier lock-in.

Cloud services are delivered by leveraging a robust control infrastructure that is always available, independent of the CSP's choices of technology and hardware. Delivering on the SDN principles of openness and abstraction, Nuage Networks optimizes the datacenter network by separating how services are defined from how they are instantiated. The solution also separates the implementation of required network services from the underlying server or datacenter networking hardware and compute virtualization environment.

Unlike early attempts to address datacenter network virtualization, where success has been limited to creating network islands of bounded scale, Nuage Networks shatters artificial boundaries of racks, clusters and even datacenter walls. Nuage Networks virtualizes resources within and across datacenters. The Nuage Networks solution enables seamless interconnection with enterprise VPNs to ensure that business endpoints are securely incorporated.

**FIGURE 3. Nuage Networks offers a new cloud paradigm that addresses enterprise needs**

	Status Quo	NUAGE NETWORKS DELIVERS What is Needed
Virtualization of network services	LAYER 2 VIRTUALIZATION	FULL NETWORK VIRTUALIZATION, L2 THROUGH L4
Breadth of Application Models	SIMPLE SCENARIOS	HYBRID CLOUD SERVICES, SEAMLESS VPN CONNECTIVITY
Availability & Scale	FRAGILE, NOT MULTI-TENANT	ROBUST, THOUSANDS OF TENANTS
Reach & Mobility of network resources	ISLANDS, WITHIN RACKS OR CLUSTERS	SEAMLESS VIRTUALIZED FABRIC, THROUGHOUT & ACROSS DATACENTERS
Network service turn-up time	SLOW, MANUAL, CONFIGURATION DRIVEN	INSTANTANEOUS, AUTOMATED POLICY-DRIVEN
Openness	SPECIFIC TO VENDOR IMPLEMENTATIONS	INDEPENDENCE FROM HARDWARE CHOICES



### **A programmable and reflexive network without bounds**

Removing the constraints from the datacenter infrastructure is the core value delivered by Nuage Networks. The benefits of the Nuage Networks solution include:

- Flexibility to conceive new application services quickly:
  - Through a programmable network infrastructure with open APIs to applications and networking elements
  - Through an abstraction layer that allows an application's network service requirements to be presented in application-centric language
  - With seamless insertion into the existing environment, working with existing compute virtualization and networking hardware
- Automation to eliminate delays in service establishment:
  - Through reflexive and touch-less instantiation of network services in a policy-driven manner
  - By combining distributed intelligence at virtual endpoints within the hypervisor with a centralized view of network resources and application policies
  - By eliminating slowdowns triggered by the creation or deletion of virtual machines within the compute infrastructure
- Multi-tenant and location-independent scaling to ensure a seamless, powerful cloud:
  - Through a single system that extends control of datacenter network resources throughout and across datacenters, as well as to enterprise locations
  - Through elegant federation of SDN controllers, using protocols proven in scaling the Internet
  - By leveraging a robust, service-oriented network control infrastructure deployed for years in residential, business and mobile service delivery within the world's largest IP and Ethernet networks

## **Nuage Networks Virtualized Services Platform**

The Nuage Networks Virtualized Services Platform (VSP) is a complete network services solution for the multi-tenant cloud datacenter and is comprised of three key functions:

- Virtualized Services Directory (VSD); advanced policy and analytics engine
- Virtualized Services Controller (VSC); network services controller
- Virtual Routing and Switching (VRS); network endpoint control

Through its three key elements, the Nuage Networks VSP participates openly in the services plane, the control plane, and the forwarding plane of the datacenter network. The VSP fully abstracts the definition and automates the instantiation of network services required by application scenarios. It does this using an IT-centric view of per-tenant policies, application preferences and network service requirements. The Nuage Networks VSP delivers full programmability via application and network APIs, and fully virtualizes and automates the existing infrastructure, including bare-metal assets.

With the Nuage Networks VSP, CSPs, web-scale operators and tech enterprises can build a robust and scalable multi-tenant networking infrastructure that delivers

Removing the constraints from the datacenter infrastructure is the core value delivered by Nuage Networks.

secure virtual slices of readily consumable compute, storage and networking across thousands of tenants and user groups.

The Nuage Networks VSP energizes the delivery of cloud services for CSPs as they build out their datacenter infrastructures with a focus on maximizing the impact of their investments and minimizing their operational costs. The result is an advanced multi-tenant datacenter that is highly programmable, automated and boundless; a datacenter that enables CSPs to achieve dramatically higher service velocity, scope and ROI. See Table 1.

**TABLE 1. Nuage Networks VSP maximizes the value of datacenter investments and minimizes operational costs**

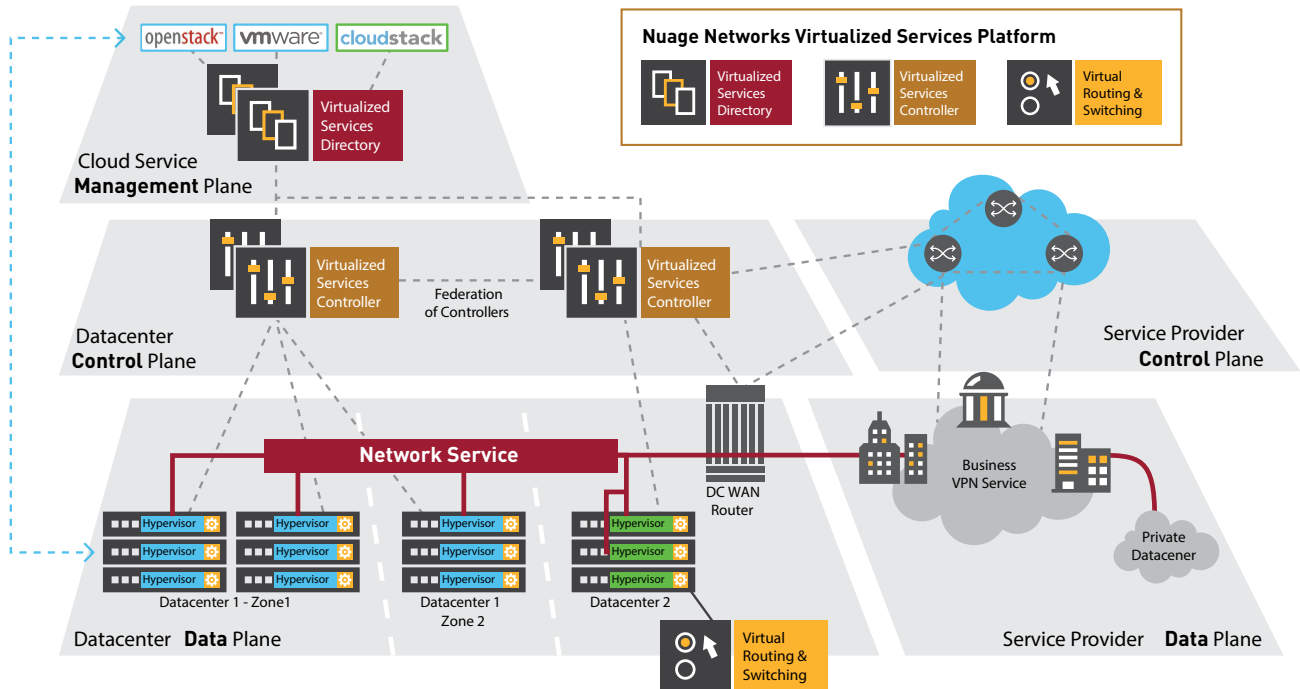
<b>Service velocity</b>	Network resources available to customers in lock-step with compute resources, eliminating operational delays that erode customer satisfaction
	New customers and new applications on-boarded quickly through application-centric service definition and creation that is decoupled from network-centric implementation details
	Per-tenant/enterprise views for self-service establishment of requirements and policies and instantiating network services automatically in line with policies and application business logic
<b>Service scope and reach</b>	Full visibility and control of the entire cloud network infrastructure, not just restricted islands within a single datacenter; view extends across multiple datacenters and includes existing enterprise VPNs
	Ability to deliver hybrid cloud services — a powerful offering to key enterprise customers
<b>Resource efficiency and improved ROI</b>	Optimized server utilization. While datacenter networking spend is nominal in comparison to server infrastructure, primitive networking approaches hold back the optimization of workload placement and reduce ROI on compute assets
	Improved network fabric utilization
	Dramatically reduced operational expenses associated with manual service configuration

## Building the unconstrained datacenter network for the cloud era

The Nuage Networks approach applies principles that have proven effective in scaling operations for the world’s largest wireless and IP networks. New technologies have been developed to enable dynamic mobility in wireless devices and secure service delivery to millions of broadband subscribers. These technologies can now be leveraged to scale cloud datacenter networks and address the challenges of networking dynamic application resources.

The Nuage Networks solution takes advantage of proven technology from the routers that scale the Internet and support thousands of enterprises on a multi-tenant VPN infrastructure today. With this heritage, the Nuage Networks solution can confidently deliver the robust and scalable performance required by cloud datacenter networks. In today's environment, where CSPs cannot afford to experiment with fragile or unproven platforms, the decade of Ethernet and IP network deployment experience that is at the heart of the Nuage Networks offering proves critical.

**FIGURE 4. Nuage Networks Virtualized Services Platform delivers datacenter network efficiencies while seamlessly connecting the wide area**



Nuage Networks is democratizing the datacenter network and in so doing has unshackled the delivery of cloud services. Technology will continue on its increasingly powerful path and the number of virtual machines per server will multiply. Enterprises will continue to look for new and innovative hybrid cloud services. Nuage Networks sets the foundation for the datacenter network to adapt to this growth and gives Cloud Service Providers the flexibility to maintain their lead in the market.



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