

# Enhancing VDI with Pluribus Netvisor<sup>®</sup>

Virtual Desktop Infrastructure Gains Fabric-wide  
Visibility and Control for Enhanced Performance

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# Summary

To deliver on the Virtual Desktop Infrastructure (VDI) promise of reducing costs, while providing users the same Quality of Experience (QoE) of a traditional desktop, IT organizations must overcome the challenges stemming from the complexity of the VDI solution and its real-time performance requirements. In the event of a problem, troubleshooting typically spans multiple organizations requiring extra steps in order to pinpoint the root cause.

While virtual desktop services greatly simplify the task of provisioning and maintaining desktop posture for all individual users, the solution requires the data center network to handle the additional North/South traffic for the resultant remote desktop sessions, plus the intense East/West storage traffic associated to the common image being accessed by all virtual desktop instances. In both cases, latency has a direct impact on the perceived Quality of Experience, so the network infrastructure must keep latency at a minimum, and be capable enough to monitor performances per each class of traffic as well as all of the individual connections.

To address the need of a large virtualized workload, Pluribus has developed a Virtualization-Centric Fabric (VCF™) architecture based on server cluster technologies. The Pluribus Netvisor® operating system (nvOS) based on VCF, runs Pluribus Freedom switches, federates into a fabric, offering fabric-wide insight, agility and security all without the need for an external controller. This paper explains how the deployment of the virtual desktop infrastructure benefits from Pluribus nvOS.

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Pluribus Netvisor® (nvOS) runs on the Pluribus Virtualization-Centric Fabric architecture based on server cluster technologies. Without the need for an external controller, nvOS federate Pluribus switches into a fabric, offering fabric-wide insight, agility and security of virtual loads.

# Introduction

Virtual Desktop Infrastructure (VDI) give employees the freedom to work from anywhere and to use any device while preserving company data isolation. IT can easily deploy new applications or provision full desktop services to the user by offering access to a data center virtual machine capable to support an individual desktop environment. The user interface of the virtual machine is transferred to each client by mean of specialized protocols such as Microsoft RDP (Remote Desktop Protocol), Citrix ICA/HDX (Independent Computing Architecture/High Definition Experience), Teradici PCoIP (PC over Internet Protocol).

Virtual machines' images are optimized in size by linking the specific environment of each individual user to a common Operating System image, with the double benefit of saving disk storage while easing the deployment of common desktop software updates to a large number of users. While virtual desktop services greatly simplify the task to provision and maintain desktop posture for all individual users, the solution requires the data center network to handle the additional North/South traffic for the remote desktop sessions and the intense East/West storage traffic associated to the common image being accessed by all virtual desktops. In both cases, latency has a direct impact on the perceived Quality of Experience, so the network infrastructure must keep latency to a minimum, and be capable to monitor performances per each class of traffic as well as all of the individual connections.

To support the need to exchange, monitor and control huge flows of data, Pluribus has developed a Virtualization-Centric Fabric architecture based in part on server cluster technologies. Without the need for an external controller, the Pluribus Freedom Series Ethernet Switches powered by Pluribus nvOS federate into a Virtualization-Centric Fabric, offering fabric-wide insight, agility and security for virtual loads. This paper explains how Pluribus nvOS enhances the deployment of **virtual desktop infrastructure** above and beyond classic Network Operating Systems.

## Pluribus Freedom Series Switches

The Pluribus Networks Freedom series switches provide best-in-class networking functionality including switching, routing, storage and analytics. This dramatically improves workload management and network agility. Pluribus Freedom spine-leaf infrastructure is particularly suitable for large VM pools with migration, big data analytics, cloud and VDI applications.

## Pluribus Netvisor® (nvOS) Innovation

Pluribus Networks advances network virtualization and software-defined networking (SDN) through Netvisor (nvOS), the industry's most programmable, open source-based network operating system. Netvisor is based upon the Pluribus Virtualization-Centric Fabric™ (VCF™) architecture, a proven approach to understanding flow, rapidly responding to business needs and securing your data. Pluribus nvOS is a distributed controller fabric:

- The fabric-wide end-point database, or vPort table, is known and accessible by all switches to simplify troubleshooting and apply policies
- QoS and security allow for granular flow filtering and security actions by vFlow programming

The Pluribus Netvisor operating system and Freedom Series of switches provides best-in-class hardware switching economics. The deployment flexibility is guaranteed by Pluribus nvOS full Layer 2/Layer 3 (L2/L3) stack with CLI providing complete interoperability with the existing networking infrastructure without the need to "rip and replace".

Pluribus nvOS Innovation	Advantage
Distributed Controller Fabric	For the past 20 years, people have configured routers and switches box-by-box via the CLI, experiencing management overhead and errors. Pluribus nvOS creates a cluster –a fabric cluster– between Pluribus switches, even across 3rd party network devices. This gives the ability to configure and troubleshoot the network as if it were a single switch, using a single secure login through one logical control point.
Application Flow Visibility	IT organizations need to ensure the ‘Application Quality of Experience,’ which includes ease of application deployment and operation, application performance, and making sure the application makes optimal use of compute, storage, network, and virtualization resources. The Pluribus Virtualization-Centric Fabric integrates analytics capabilities to offer a real-time view into all application flows at the host and VM level. Latency, packet loss, and connection durations are all available to create a complete picture.
vPort	While a legacy Ethernet switch is only aware of the devices connected to its own ports, Pluribus nvOS maps each end-point to a vPort. The vPort is a record in a fabric-wide database, which gives the ability to track port attributes across the fabric, even over a specified time range. The vPort record may store simple information, as the IP address to MAC address mapping, but it may be used to store additional endpoint metadata as the hostname, the OS and the hardware configuration to easy end-to-end application troubleshooting. When a VM migrates from one server to another, the vPort record is updated and any associated policy follows the endpoint.
vFlow	Enforcing security and applying QoS require control over network flows, for any arbitrary combination of physical ports, L2, L3 and L4 information. Pluribus vFlow offers granular visibility and control over network traffic: even without a controller the configuration is applied across the whole fabric, not per switch. Flow programming is based on matching conditions, for example source/destination IP, protocols, ports etc. with actions, which could include drop, limit bandwidth, redirect, mirror, trap, change VLAN/VXLAN, encapsulation or copy to CPU.

## VDI Business Requirements

Organizations that deploy Virtual Desktop Infrastructure (VDI) expect to reduce costs and enhance security, while providing users the same QoE (Quality of Experience) of a traditional desktop.

Cost reduction is tied to overall operation simplification in managing, configuring and keeping up-to-date a farm of virtual machines, rather than the individual users’ physical desktops. In addition, achieving a justifiable cost reduction may require sharing physical resources, such as the Operating System image’s storage, across all virtual desktops. Desktop composition causes high network traffic, especially at the start of the working day, when all users are booting up their desktops. The infrastructure must handle this condition and keep the boot time within acceptable limits for each user.

The QoE has a direct impact on the user productivity, so it is not negotiable. The desktop is a critical working tool; its use is not limited to traditional office applications, but also includes multimedia for personal communication or training. QoE depends on various components, such as the quality of the wide area connection between the user and the virtual desktop. In the datacenter, QoE can be sensitive to compute capacity, storage and network latency. In case of service complaints, ticket resolution may require cooperation between the LAN/WAN network administrator, the datacenter network administrator and the virtual infrastructure administrator. To limit user frustration and productivity loss, all infrastructure components should offer effective visibility and troubleshooting tools for such a complex scenario.

# Network Design Considerations for VDI

The business requirements drive the network design considerations, from the architecture to the operation and management features.

## Typical Network Architecture for VDI

A modern datacenter network POD architecture is based on a spine and leaf topology as illustrated in Figure 1: the top of rack (ToR) switches are the leaf switches and they are attached to the core switches as the spine. The leaf switches are not connected to each other and spine switches only connect to the leaf switches (or an upstream core device). In this architecture, the number of uplinks from the leaf switch equals the number of spine switches. Traffic from a leaf always crosses two links and it is evenly balanced across all spines, with advantages in terms of performance, availability and predictable end-to-end network latency when compared to a legacy three-tier design. Availability is provided by link aggregation between the compute nodes and the leaf switches, and between the leaf and the spine switches. Leaf and spine switches may be deployed in pairs using the multi chassis link aggregation (MLAG) technology to remove any single point of failure (not shown in Figure 1).

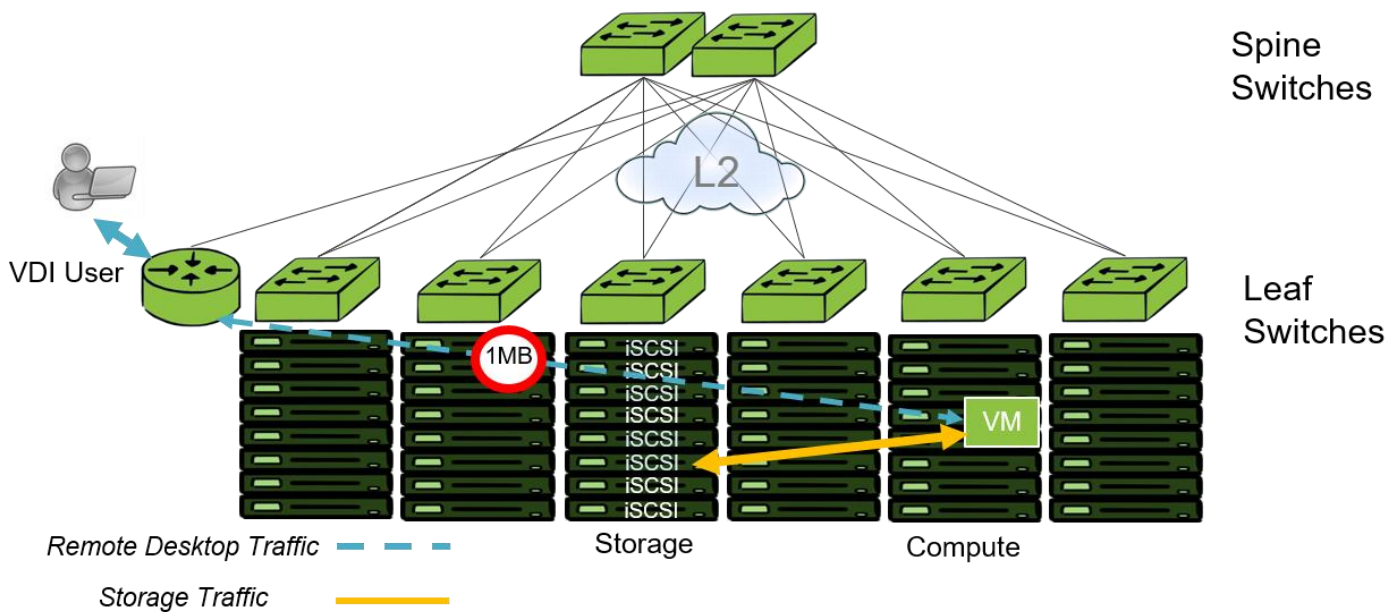


Figure 1: Spine and leaf network architecture for virtual desktop infrastructure

The leaf-spine design is capable of true linear scaling with consistent performance since communication between any two racks will always require two hops. To scale out, additional racks may be added by simply adding spine and leaf switches without any impact on available bandwidth. The spine-leaf architecture, under normal load, provides equal and predictable latency to all nodes and constitute a solid foundation for supporting the virtual workload of a VDI deployment.

## Traffic flows in a VDI deployment

In a typical VDI deployment, a set of racks, or POD, provide virtual desktop services to thousands of users. Within the POD, the layer 2 networks allows for virtual machine migration. For the most part, VDI traffic may be divided into two components:

- **Traffic in-and-out of the POD** (also known as North/South) - Virtual desktop remote access, directed to the core network to be routed to users outside the data center. It includes any real time media the end user may retrieve from his virtual desktop.
- **Traffic within the POD** (also known as East/West) - access to shared IP storage, using storage protocols such as iSCSI.

The network latency, including both North/South and East/West components, has direct impact on the user experience, so it should be carefully monitored and maintained within an acceptable range.

## Enhancing VDI Network Operations with Pluribus nvOS

The Pluribus Netvisor operating system running on Pluribus Freedom switches offer unique features to the data center network architect and administrator:

Pluribus nvOS unique features:	Benefit in a VDI deployment
Feature-rich L2/L3 and multicast	Assured interoperability with legacy devices to offer flexible design options when deploying a new VDI POD
Fabric-wide single point of management via CLI and/or API without the need of a controller: the entire fabric is seen as a single switch	Management of each end-point/VM allows maximum agility since it doesn't require knowledge of the attachment point. Automation –in integration with customer applications–is independent with respect to changes in the infrastructure
Integrated or tap-less fabric provides visibility into end-to-end application flows	Powerful troubleshooting tools, suitable for a dynamic environment, include an extensive set of built-in network telemetry and provide indicators on VDI user QoE, desktop performance and storage
vPort host/end-point identity and location database	Fabric-wide consolidated view of end-points /VMs to simplify troubleshooting and anchor policies
vFlow commands set to select and control data flows	Administrator can identify individual flows or classes of flow to apply QoS and security policies fabric-wide

# Addressing VDI Network Challenges with Pluribus nvOS

The following table summarize the benefits of Pluribus nvOS for VDI operation:

VDI Aspect	Challenge	Pluribus nvOS solution
New VDI deployment in an existing data center	In third-party datacenter environments, VDI racks communicates via legacy core, connection broker in a legacy network	Pluribus nvOS provides fabric-wide visibility and control in both new and third party deployments (including a combination of racks with legacy ToRs and racks with Pluribus nvOS ToRs). The familiar CLI also allows for easy insertion into traditional network environments.
Remote desktop session SLA	Asses performance of display protocol sessions	Fabric-wide client-server flows (TCP, UDP) telemetry and latency analysis (TCP)
Remote desktop session bandwidth	Assure a fair use of bandwidth across clients: prevent excessive traffic due to a client misconfiguration	Fabric-wide bandwidth control to specify min guarantee and max allowed bandwidth. Fabric-wide top-talker application
Troubleshooting	Is the network slow? Or the storage, or compute? Problem isolation is challenging due to the complexity of the architecture that involve multiple teams within the Enterprise	Integrated, tap-less telemetry and application monitoring based on fabric-wide ability to track network application flows and client-server connections to pinpoint the trouble area
IP storage traffic	Prevent and/or detect hot spots as in bootstrap storms	Flow congestion report (flowtrace) and client-server connections analysis for iSCSI/NFS

## Pluribus nvOS Deployment Options

Each switch in the fabric locally computes the state with traditional L2/L3 network protocols (such as STP, BGP, OSPF), providing interoperability with the legacy infrastructure. As a consequence, Pluribus Freedom switches with Pluribus nvOS may be deployed as TORs for all racks or for a subset of the racks, as well as deployed as spine switches. This offers maximum flexibility in network design:

- **New Deployments:** Deploy a network POD entirely composed by Pluribus switches with Pluribus nvOS, including spine and leaf switches
- **Third Party Deployments ToR:** Deploy ToR Pluribus switches with Pluribus nvOS in each rack
- **Third Party Deployments POD:** Insert a set of racks with Pluribus switches with Pluribus nvOS ToRs to support a specific application as desktop virtualization, within a legacy network built with third party devices as spine and leaf switches

In the presence of third party legacy switches, all Pluribus switches can still form a seamless fabric, providing there is L2 or L3 connectivity between the management interfaces or in-band.

Pluribus nvOS provides design options in deploying the virtual desktop infrastructure: each rack adopting a Pluribus nvOS ToR interoperates with the datacenter infrastructure, while providing a single point of control and end to end visibility and telemetry. By logging into any of the Pluribus nvOS ToR, the administrator can introduce fabric-wide policies.



Examples of such policies include assigning upper and lower bandwidth limits to desktop sessions or prioritizing storage traffic.

## Fabric Design with Pluribus nvOS in New Deployments

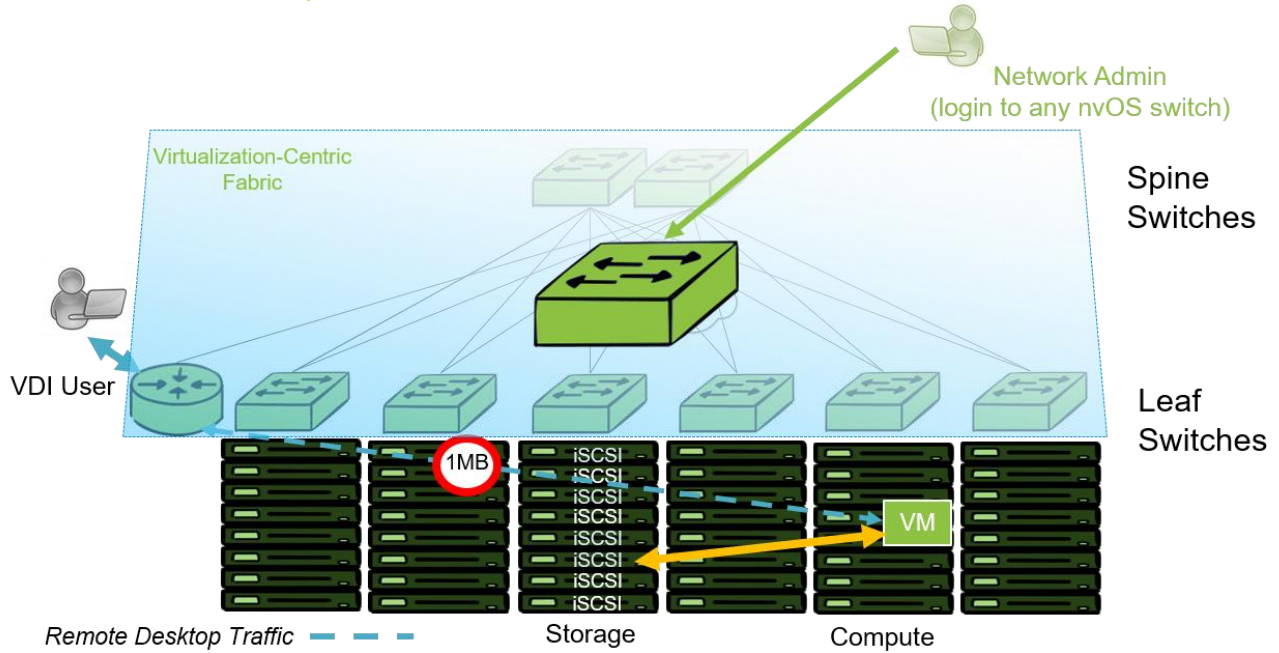


Figure 2 - VDI deployed with Pluribus nvOS: the fabric offers a single point of control as if it were a single switch

## Leaf Deployment with Pluribus nvOS

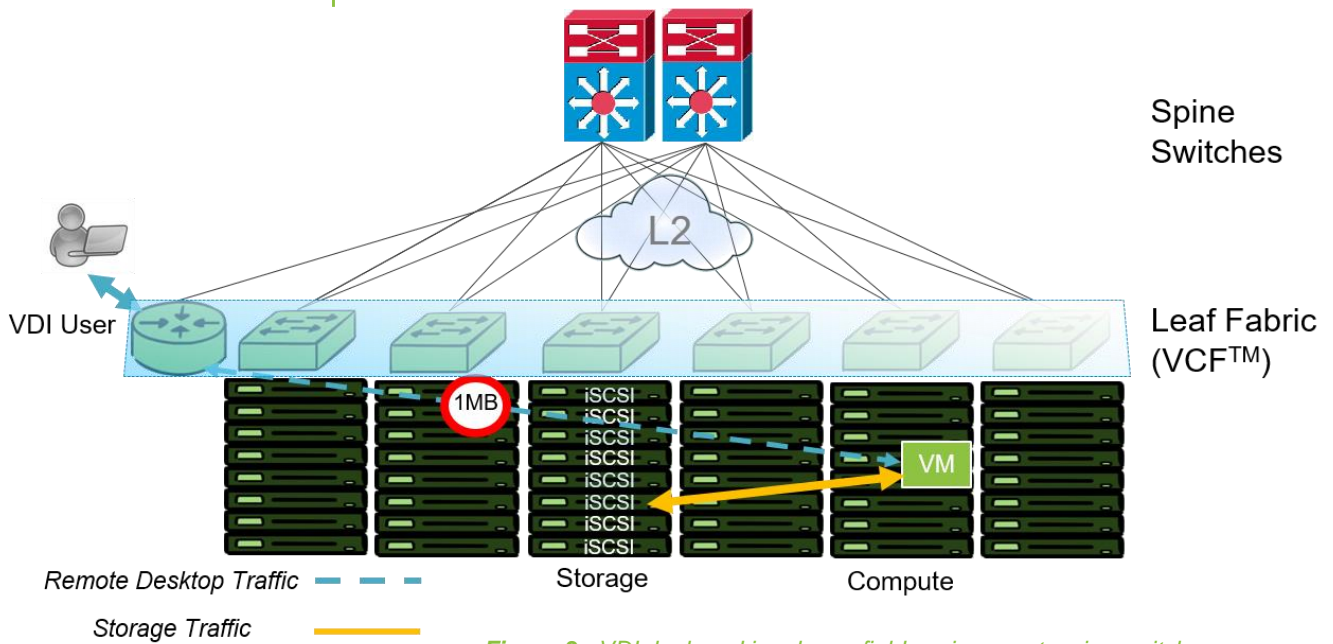


Figure 3 - VDI deployed in a brownfield environment: spine switches are legacy switches, ToRs are a fabric of Pluribus switches

# Pluribus Virtualization-Centric Fabric, Distributed Controller

The Pluribus Virtualization-Centric Fabric (VCF™) is a distributed architecture, based on a collection of compute clustering techniques which presents an open, standards-based Ethernet fabric as one logical entity, simplifying the management, monitoring, virtualization and programming of the network fabric. Pluribus Netvisor can cluster under a single logical switch any combination of Pluribus Freedom Series switches.

Each switch locally computes the network topology state with traditional L2/L3 network protocol, then each switch relies on the clustering algorithms to replicate its “view” of the network fabric to all the other peer switches in the cluster. As a result every switch in the cluster has the same knowledge of the state of the entire fabric: host MAC address, host IP address, ports, connection flows, network resources, etc. The cluster forms a “multi-box virtual switch” to dramatically simplify network management. Any node in the network can act as the central point of management and control for the entire cluster.

The Pluribus Virtualization-Centric Fabric is not a replacement of open, standards-based network protocols to build a network fabric, but rather it is a complementary software architecture to augment the network’s capabilities above and beyond L2/L3 connectivity.

The network administrator can easily access, from any of the Pluribus switches, fabric-wide telemetry information to identify the VDI storage traffic, the remoted desktop sessions, apply policies and review the topology.

## Programmability

Pluribus Netvisor offers developers the ability to monitor and control network resources (e.g. ports, VLANs, MACs etc.), network services and individual application flows with a simple and powerful API. Programming options, beyond the CLI include C, Python, Java and RESTful API, providing an easy integration with the application layer.

With the programmable API, it is possible to program application flows and control network resources fabric-wide. The network can be treated as a single programmable switch. This approach further simplifies application integration.

Since the fabric offers a single point of control, simple scripts can access fabric wide information to take real-time action beneficial to the entire cluster. Telemetry information, QoS and bandwidth allocation are available via this point of control.

The programmable Pluribus nvOS Virtualization-Centric Fabric provides an initial set of applications, including fabric-wide Pluribus TopTalkers and FlowTrace. Top Talkers provides a list of end points ordered by their traffic volume. FlowTrace provides the list and detailed congestion status of the input/output ports of all switches traversed by a given data flow - valuable information to identify and prevent congestion during a bootstrap storm. Pluribus applications are accessible to the network administrator via CLI and via programmatic API.

## Visibility and Control: vPort and vFlow

Pluribus Netvisor provides advanced capability to monitor and control traffic directly in the network fabric.

- End point information is represented as vPort objects, organized into a single fabric-wide table that includes basic physical topology information. The vPort record schema may be programmatically extended to include application specific metadata such as server type and OS.

Every switch in the cluster has the same knowledge of the state of the entire fabric...The cluster forms a “multi-box virtual switch” to dramatically simplify network management.

- Traffic is identified, monitored and controlled referring to fabric-wide objects called vFlow.
- Performance related telemetry, such as average latency, is readily accessible referring to “connection” and “client-server” objects.

Traffic visibility and control features are available via CLI as well as via programmatic interface for easy integration with the application logic. Netvisor provides fabric-wide traffic control and visibility, with monitoring capabilities for all network events. Traffic control includes rate limiting, access control and redirection. When applied to VDI, the visibility and control features in Pluribus nVOS have several applications, such as:

- The vFlow feature supports wildcards that allows to control the flow associated virtual desktop sessions and allocate a bandwidth compatible with providing a good QoE to all users.
- The “connection-show” and “client-server-stats-show” commands allow the identification of storage traffic and the visualization of performance parameters useful to pinpoint the source of a QoE problem.

Track application flow congestion statistics, port statistics, timestamps, flow latency and even flow paths across the fabric from any node.

## Integrated Network and Application Flow Telemetry

Pluribus nVOS runs inside the physical network, which is at the crossroad of all the transactions: the ideal location for monitoring the infrastructure. Pluribus nVOS network telemetry and visibility is valuable in multiple cases:

- Reduce the mean-time-to-troubleshoot network issues.
- Identify deviation from normal to flag potential security issues and support auditing.
- Create a baseline for capacity planning.
- By embedding sophisticated telemetry directly inside the network switches, Pluribus nVOS eliminates the need for a redundant monitoring infrastructure, cutting the costs for separate monitoring taps, probes and a dedicated “visibility” fabric.

Examples of Pluribus analytics capabilities are:

### Host locator

- Ability to locate fabric-wide hosts from any node – both physical and virtual
- Trace VM migrations fabric-wide from any node
- Reports the specific switch and ToR port where the host is connected to enable location based logic

### Application Flow Telemetry

- Track application flow congestion statistics, port statistics, timestamps, flow latency and even flow paths across the fabric from any node
- Very accurate –not based on sampling– fabric-wide “Netflow”
- Fabric-wide capabilities are particularly relevant in a very dynamic environment such as VDI: a client may be redirected to any server in a connection broker farm, non-persistent virtual desktops are associated with the user on the fly, virtual desktops workload may be relocated at any time to balance the servers’ load, and storage traffic spreads across multiple paths. Pluribus nVOS visibility doesn’t require knowing in advance the attachment point of the objects to be observed, but it provides results based only on the search criteria, such as the address or the traffic type.

# Conclusions

To deliver on the VDI promise of reducing costs, while providing users the same Quality of Experience (QoE) of a traditional desktop, IT organizations face challenges related to the complexity of the solution and the real-time requirements. In case of problems, troubleshooting spans across multiple organizations and requires extra steps in order to pinpoint the root cause.

Pluribus Netvisor running on Pluribus Freedom switches provides a superior level of visibility and control and fabric-wide management access through a single point. Both CLI-based management and API programmatic access are greatly simplified by accessing a consolidated view of the entire fabric, bringing ease-of-use and simple application integration.

Based on open networking standards, the Pluribus solution offers unparalleled fabric visibility and control for the virtual desktop infrastructure with industry leading economics.



# About Pluribus Networks

Pluribus Networks provides data center solutions that allow your business to run unconstrained. Our software-defined, open networking, fabric-based solutions transform existing network infrastructures into flexible and strategic assets fully aligned with today's digital business needs. Our Virtualization-Centric Fabric (VCF™) architecture provides unprecedented insight, agility and security to customers seeking to simplify operations, run more cost effectively and bring new applications online faster.

Learn more at [www.pluribusnetworks.com](http://www.pluribusnetworks.com) and [@pluribusnet](https://twitter.com/pluribusnet).

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