Windows Server 2012 R2 Networking

Technical Scenarios and Solutions

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Rethinking Networking with Windows Server 2012 R2

Overview

The exponential growth of available data has created significant challenges for information technology (IT) storage. For company networks, big data is consistently increasing network demands. This reality along with today's heavily virtualized infrastructures is heavily impacting network performance.

Networking enhancements in Windows Server 2012 R2 however, help you more easily virtualize workloads, improve security, provide continuous availability to applications, and get better performance out of existing resources. These enhancements help improve virtual machine density, mobility, and availability.

The purpose of this whitepaper is to explore different network challenges and reveal how new and enhanced features in Windows Server 2012 R2 addresses each one of them. This paper will also illustrate at length how to scale out Hyper-V servers, and the workloads that run on them, in a multi-tenant environment. This scenario includes all the services and features that combine to deliver scalable, reliable, and highly-available applications.

The following diagram provides a quick view of some of the new and enhanced storage features of Windows Server 2012 R2 and System Center 2012 R2:

Layer	Feature	Description
Software-Defined Networking	Hyper-V Network Virtualization	Provides a layer of abstraction between the physical networks that support the hosts, and the virtual networks that support the virtualized workloads. As a result, datacenters can handle multiple virtual networks with overlapping IP addresses on the same physical network.
Software-Defined Networking	Hyper-V Extensible Switch	Offers an open development framework for adding Layer 2 functionality such as filtering, monitoring, and packet-level redirection required by the application or tenant to connect virtual machines to the physical network.
Software-Defined Networking	Multi-Tenant Virtual Private Network (VPN) Gateway	Extends virtual networking environments outside of the private datacenter to a hosted cloud environment using Network Virtualization using Generic Routing Encapsulation (NVGRE) routing.
Software-Defined Networking	Network Switch Management with Open Management Infrastructure (OMI)	Offers a Distributed Management Task Force (DMTF) standard for datacenter devices and platform abstractions.
Software-Defined Networking	Partner Ecosystem for Software-Defined Networking	Provides Partner Solutions for various components of physical and virtual networking.
Continuous Availability	Network Fault Tolerance with Server Message Block (SMB) Multichannel	Offers redundant network path support for SMB sessions.
Continuous Availability	Highly Available Dynamic Host Configuration Protocol (DHCP) Service	Delivers failover support for enterprise DHCP services in either a load-sharing or hot-standby mode.
Continuous Availability	Network Quality of Service (QoS)	Offers management of available virtual machine bandwidth using a policy that moves with the virtual machine during virtual machine migration.
Continuous Availability	Network Interface Card (NIC) Teaming	Provides Load Balancing/Failover (LBFO) support inbox for any group of NICs.
Performance with Next-Generation Hardware	SMB Direct Remote Direct Memory Access (RDMA)	Takes advantage of RDMA NICs and performs central processing unit (CPU) offload for network-heavy workloads.
Performance with Next-Generation Hardware	Virtual Receive Side Scaling (vRSS)	Provides efficient CPU distribution of receive-side network processing tasks. VRSS can be extended into a virtual machine with multiple logical processors.

Performance with Next-Generation Hardware	Dynamic Virtual Machine Queue (VMQ)	Dynamically allocates processor cores for efficient processing of Hyper-V virtual switch requests.
Performance with Next-Generation Hardware	Single Root I/O Virtualization (SR-IOV)	Boosts network performance on virtual machines with SR-IOV capable NICs. The feature handles NIC function calls directly from the virtual machine.
Simplified Manageability	Windows Server 2012 R2 IP Address Management (IPAM)	Provides in-box IP address space and service management infrastructure that supports virtual networking address spaces.
Simplified Manageability	Windows PowerShell Support	Offers across-the-board automation and scripting environment.
Simplified Manageability	Hyper-V Resource Metering	Tracks and reports for Hyper-V resource management and tenant resource consumption.
Simplified Manageability	Hyper-V Remote Live Monitoring	Monitors network traffic on a remote server.
Simplified Manageability	System Center 2012 R2 Virtual Machine Manager	Delivers virtual machine management and service deployment capabilities. Virtual Machine Manager supports multi-hypervisor environments and enables you to define, create, and manage the datacenter environment.
Simplified Manageability	System Center 2012 R2 Operations Manager	Ensures the datacenter organization can provide the necessary insight to deliver predictable service level agreements to application owners.
Hybrid Cloud Networking	Cross-Premises Connectivity	Offers secure site-to-site (S2S) gateway services that support multiple clients and VPNs for cross-premises connectivity between enterprises and hosting-service providers.
Hybrid Cloud Networking	Connecting Private Cloud with Windows Azure and Hoster	Provides secure, multi-tenant virtual networking gateway services to Windows Azure that supports isolation and NVGRE routing of virtual network traffic.

Challenges

A major challenge for IT professionals today is keeping up with constantly increasing network demands emanating from the exponential growth of corporate data. With the influx of big data and social networking data, IT staffs must find efficient methods to create, store, report on, and archive information. Adding to the challenge are evolving infrastructures that IT must integrate into their existing environments. For example, incorporating private and public cloud implementations is a relatively new component that many companies want to utilize in the workplace. Some of these moving parts overlap with no clear lines to delineate the best path to choose.

Within this framework, more and more companies are turning to virtualization as a viable solution. To this end, IT staffs must find effective resources for integrating virtualization into their current architecture. This can present many challenges. Some of the most notable within a large, multi-tenant environment are as follows:

- Physical networks lack the flexibility of software-defined networks
- Continuous availability (CA) of applications and guaranteed Quality of Service (QoS) must extend beyond the datacenter into hosted environments with end-to-end network monitoring and troubleshooting tools
- Virtual workloads need to take advantage of hardware innovations such as non-uniform memory access (NUMA) and Remote Direct Memory Access (RDMA)
- Customers need to get maximum performance from existing hardware

Introducing Windows Server 2012 R2 Networking

Windows Server 2012 R2 introduces many new and enhanced virtual networking technologies that enable easier setup, management, and troubleshooting of Hyper-V Network Virtualization infrastructures. With Hyper-V Network Virtualization, companies gain a much-needed layer of abstraction between the physical networks that hosts run on and the logical networks that virtualized workloads run on.

Physical networks need to be able to support and isolate multiple virtual networks. Virtual networks need to be able to span multiple physical networks. These needs go beyond private VLAN (PVLAN) setup. Hyper-V Network Virtualization provides this flexibility with advanced packet filtering and routing through the Hyper-V Extensible Switch, multi-tenant gateway services, and System Center 2012. The Hyper-V Extensible Switch offers customers and partners an open development framework for adding Layer 2 functionality such as filtering, monitoring, and packet-level redirection needed to fulfill the requirements of the application or tenant.

Server Message Block (SMB) Multi-Channel and Network QoS help improve application availability over physical and virtual networks by guaranteeing that multiple paths are available to application shares and that there is enough available bandwidth reserved for the application to function at levels set forth by the service level agreement (SLA).

In addition, improvements to network infrastructure availability such as Dynamic Host Configuration Protocol (DHCP) Failover help ensure that DHCP services never go down. Windows Server 2012 and higher DHCP Servers can now operate in a failover relationship with a partner DHCP server. The partnership can operate in either a load-sharing mode (fault tolerant), or hot standby mode (highly available). This functionality gives network administrators the ability to have their enterprise DHCP scopes serviced by a topology of DHCP Servers.

To take advantage of new industry-standard hardware technologies within virtualized workloads, Windows Server 2012 and Windows Server 2012 R2 support Remote Direct Memory Access (RDMA) to file servers through the implementation of SMB Direct. For virtualized workloads with heavy networking demands, Single Root IO Virtualization (SRIOV) connects the physical NIC or team used on the host directly to one or more virtual machines. This capability speeds the throughput to the virtual machine by bypassing the Hyper-V Virtual Switch and mapping NIC virtual functions directly to the virtual machine network adapter.

Windows Server 2012 R2 also offers Receive Side Scaling (RSS). With RSS, the processing job of clearing network buffers is spread across all CPU's. In Windows Sever 2012, this was limited to the host machine. Virtual Receive Side Scaling (vRSS), another new feature, builds on RSS by extending this capability to the virtual machine and enabling you to use all virtual processors assigned to the virtual machine to clear network buffers for the virtual machine. This change substantially increases the networking capabilities of virtual machines on a host by eliminating CPU bottlenecks that can limit 10 and 40 gigabyte (GB) Ethernet throughputs.

For scalability, Windows Server 2012 R2 offers IP Address Management Server (IPAM), a centralized or decentralized management console that can manage, track, and report on all aspects of a datacenter's IP address space. IPAM can manage server groups of DHCP and domain name system (DNS) servers from a central console capable of applying changes to groups of servers at once. In addition, Windows PowerShell gives network administrators the ability to set up script and deployment options for advanced services. Windows PowerShell also reduces the need for interface training as well as the risk of configuration errors. System Center 2012 R2 Virtual Machine Manager (SCVMM) also greatly improves private cloud and virtual machine manageability by providing a single control plane to manage and compute storage and networking needs at scale.

To close the gaps between on-premise Hyper-V hosts and hybrid cloud environments offered by hosters, Windows Server 2012 R2 provides Cross-Premise Connectivity to a variety of hosters along with services and tools that seamlessly extend your private cloud to Windows Azure.

This whitepaper focuses on five categories of features and services that make these capabilities possible:

1. Advanced Software-Defined Networking
2. The Delivery of Continuous Availability
3. High Performance Networking
4. Simplified Data Center Management
5. Networking in the Hybrid Cloud

For more information on all Windows Server 2012 and Windows Server 2012 R2 networking features, see: http://technet.microsoft.com/en-us/library/hh831357.aspx

Software Defined Networking

With software-defined networking (SDN), you enable software to dynamically manage your network. SDN does not mean replacing your existing network devices with new SDN-aware devices. In most cases, the most flexible and cost-effective network infrastructure is the one you already own. If your network can scale to meet the needs and demands of a modern datacenter, then there's less of a pressing need to turn to SDN. In many instances however, companies must deal with inflexible, hard-wired solutions that are complex and expensive to update. In these instances, a company can take one of two approaches to address these challenges:

- Isolate virtual networks/network overlays
- Centralize controllers

Isolated virtual networks/network overlays sit on top of the physical network, abstracted from the underlying networking hardware. Since virtual networks are software defined, administrators can create and manage them from a centralized location. Depending on the needs of the application, you can use templates for easy deployment and replication across the datacenter. This capability helps greatly reduce management overhead. In addition, many mundane, error-prone tasks become automated as a part of the virtual network definition. Customers utilize existing hardware investments without the need to change the way applications are written. Hyper-V Network Virtualization and VMware's Nicira serve as two examples of solutions that fall within this category.

Centralized controllers manage the physical network infrastructure directly from a single location. This functionality often gets paired with an Application Program Interface (API) for programming the network, giving software and potentially even applications the ability to program and dynamically configure the network on the fly depending on current needs. Such a solution requires switches and routers to expose these functionalities (Southbound APIs) and a standardized interface for applications to consume them (Northbound APIs). OpenFlow and Cisco One Platform kit offer examples of such an approach. Since software directly configures the network, it needs to be rewritten to make use of this functionality. Custom applications that run within large datacenters, network diagnostic tools, apps that require high-fidelity connections, and so on can perform better with such fine-grained control.

The cornerstone of SDN is network virtualization. Network virtualization helps you isolate virtual machines from one another as well as bring virtual machines together into common virtual networks that can span physical Internet protocol (IP) subnets or physical datacenters. Network virtualization uses encapsulation and virtual network ID headers to filter and route virtual machine-to-virtual machine traffic based on policy. To overcome the proximity limitations of physical VLANs, network virtualization routes packets between two virtual machines on the same virtual network, even if those two virtual machines are in separate datacenters. Network virtualization also helps you meet the requirements of your applications and workloads by giving you the ability to abstract them from the underlying physical network infrastructure.

Analogous to server virtualization, you need consistent and repeatable logical network abstractions that work with your applications and workloads in a non-disruptive manner while maintaining consistency across the tenant and hoster address space. For instance, you would need virtual abstractions for your physical network elements, such as IP addresses, switches, and load balancers in a multi-tenant scenario. Additionally, network virtualization gives you the ability to centrally define and control policies that govern both physical and virtual networks, including traffic flow between them. The ability to implement these network policies in a consistent manner, at scale, even as new workloads are deployed or moved around across virtualized or physical networks provides the core of SDN functionality.

With SDN, logical networks overlay physical networks. This capability provides a higher degree of control and flexibility than the physical network could deliver alone. Network virtualization gives IT pros the flexibility and control to configure the network to support any landscape and the automation needed to make changes repeatable to other virtual networks.

One of the core enablers of SDN is the Hyper-V Extensible Switch. The Hyper-V Extensible Switch is an open platform for partners and customers to add functionality on top of the already rich virtual switch feature set. The goal is to use the power of software to perform activities such as forwarding, filtering, and capturing packets.

With multiple services sharing the same physical network infrastructure, the need to isolate traffic and communication between virtual machines and services has never been more important. Windows Server 2012 R2 helps you more easily troubleshoot, isolate, and fix issues through better interaction with storage, network, and server administration tools. Since physical networks are not nearly as flexible as virtual networks, the virtual networks you create, with Hyper-V Network Virtualization, mask the complexities of the underlying physical infrastructure from those that are responsible for provisioning workloads.

Hyper-V Network Virtualization

The concept of network virtualization is not new to most administrators. Many have always relied on physical networks and VLAN's to provide connectivity and isolation of network services. Now that the landscape has changed to support private and hybrid cloud computing environments however, there are new challenges that IT staffs must face.

At a glance: Hyper-V Network Virtualization

- Creates abstractions of the physical network and the network the virtual machine communicates on
- Offers repeatable virtual network deployments based on policy
- Is available with Windows Server 2012 R2 and System Center 2012 R2 Virtual Machine Manager
- Provides easy tenant isolation and external hoster integration

Virtualization Challenges

- Tenant virtual machine isolation
- The difficulty deploying virtualized, isolated networks
- Production switch requirements change whenever an isolation boundary moves
- VLANs cannot span multiple subnets, which limits the number of nodes in a single VLAN and restricts the placement of virtual machines based on physical location

Solution

With the rise of multi-tenant virtualization environments, companies must isolate one tenant's resources from another's without having to make expensive and complicated changes to the physical network infrastructure. Customers need to have the ability to employ a layer of abstraction over the physical network that mimics the network's performance. For example, a company may want to have networks for development, testing, and production, driven by policies, which are specific to each department.

Advances in virtualization and storage technologies are making it easier to virtualize compute, network, and storage assets. With Hyper-V Network Virtualization, Microsoft extends the concept of server virtualization to enable the deployment of multiple virtual networks, potentially with overlapping IP addresses, on the same physical network. IT can set policies that isolate traffic in a dedicated virtual network, independent of the physical infrastructure.

Virtual Machine Isolation

Isolating virtual machines or entire networks of virtual machines of different departments or customers can be a challenge on a shared network. Traditionally, companies use VLANs to isolate networks. VLANs however, can be very complex to manage on a large scale.

Because most network traffic uses TCP/IP, the IP address is the fundamental address used for Layer 3 network communication. Unfortunately, when you move an IP address space to the cloud, the addresses must be changed to accommodate the physical and topological restrictions of the datacenter. Renumbering IP addresses is cumbersome because the associated policies based on the IP addresses must also be updated. The physical layout of a datacenter influences the permissible potential IP addresses for virtual machines that run on a specific server, blade, or rack in the datacenter. A virtual machine provisioned in a datacenter must adhere to the choices and restrictions regarding its IP address.

Datacenter administrators typically assign IP addresses from the datacenter address space to the virtual machines. This forces virtual machine owners to adjust their isolation policies, which were based on the original server IP addresses. This renumbering becomes so complex that many enterprises choose to deploy only new services into the cloud, leaving existing applications unchanged.

Hyper-V Network Virtualization gives each virtual machine two IP addresses; the customer address (CA) and the provider address (PA).

- The CA is the IP address that the customer assigns based on the customer's own intranet infrastructure.
  - This address is used by the customer's virtual machines and applications to maintain consistency to the customer IP address space.
  - The CA is visible to the virtual machine and reachable by the customer.
- The PA is the IP address that the host assigns based on the host's physical network infrastructure.
  - The PA appears in the packets that go out onto the wire (versus being routed internally by the Hyper-V Switch).
  - The PA routes the packets to the correct physical host that the destination virtual machine is on. The PA is visible on the physical network, but not to the virtual machine.
  - The layer of CAs is consistent with the customer's network topology, which is virtualized and decoupled from the underlying physical network addresses, as implemented by the layer of PAs.

You can use Hyper-V Network Virtualization to overlay two virtual networks over the same PA address space and keep them completely isolated from one another because of the layer of abstraction defined by the network virtualization policy (see Figure 1). Two Hyper-V hosts communicate with each other using the PA address space, while the virtual machine-virtual machine traffic only hits the wire if the destination virtual machine is on a separate Hyper-V host. The virtual network header is put on the packet so that is can be delivered by the Hyper-V switch on the destination Hyper-V host. The encapsulation protocol at work here is NVGRE (discussed shortly).

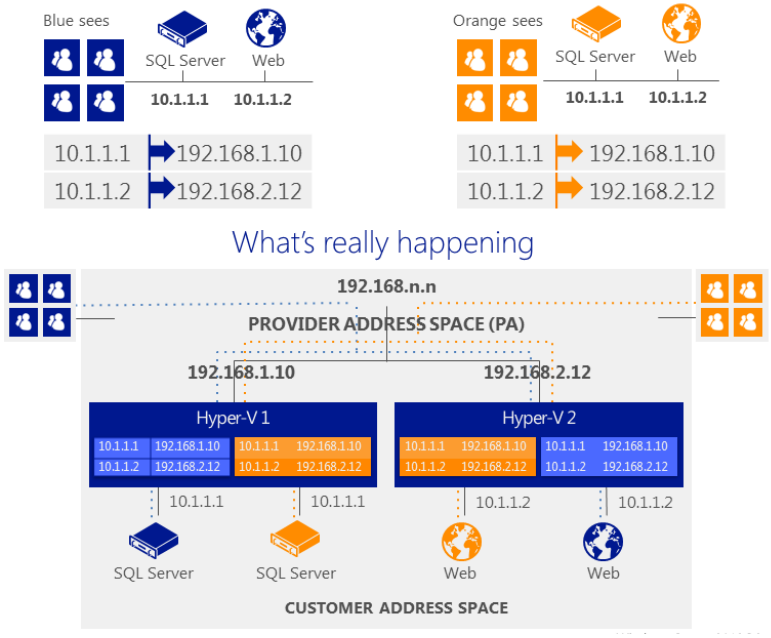

Figure 1: Using HNV to overlay two virtual networks over the same PA address space.

Hyper-V Network Virtualization Packet Flow

Hyper-V Network Virtualization enables you to break down the packet flow over two Hyper-V Network Virtualization networks using the Network Virtualization using Generic Routing Encapsulation (NVGRE) protocol. NVGRE provides a network virtualization method that uses encapsulation and tunneling to create large numbers of VLANs for subnets that can extend across a dispersed datacenter. The purpose is to enable the sharing of multi-tenant and load-balanced networks across on-premises and cloud environments.

NVGRE was designed to solve problems caused by the limited number of VLANs that the IEEE 802.1Q specification could enable. This limitation often proved inadequate for complex virtualized environments, making it difficult to stretch network segments over the long distances required for dispersed data centers.

NVGRE includes key features such as identifying a 24-bit Tenant Network Identifier (TNI) to address problems associated with the multi-tenant network and using a Generic Routing Encapsulation (GRE). The TNI helps create an isolated Layer 2 virtual network that may be confined to a single physical Layer 2 network or extend across subnet boundaries. NVGRE also isolates individual TNIs by inserting the TNI value in the GRE header.

The Network Virtualization (NV) Filter plays a critical role in this process by interrogating packets passing through the Hyper-V Virtual Switch to determine the virtual subnet ID (VSID) and verify that the virtual machine can communicate with that VSID/virtual machine prior to sending the packets on their way. The packet does not traverse the physical network if the destination virtual machine is local.

Figure 2 shows a 10.10.10.x subnet on the BLUE virtual network (which represents a customer or tenant). It has two isolated virtual machines on it (Blue1 and Blue2). The virtual network spans two physical IP subnets (192.168.2.X and 192.168.5.X). Each virtual machine is on a different Hyper-V host, which sits on the provider's physical IP network of 192.168.X.X. Even though the two Hyper-V hosts are on separate physical IP networks, the virtual network provides secure Layer 2 communication between the two virtual machines using the Hyper-V Virtual Network and NVGRE encapsulation.

Figure 2: The process of sending a packet from Blue1 to Blue2.

Figure 3: Blue1 sends the ARP Packet to locate 10.10.10.11. The ARP request is read by the virtual switch to determine if it needs to go out over the physical network.

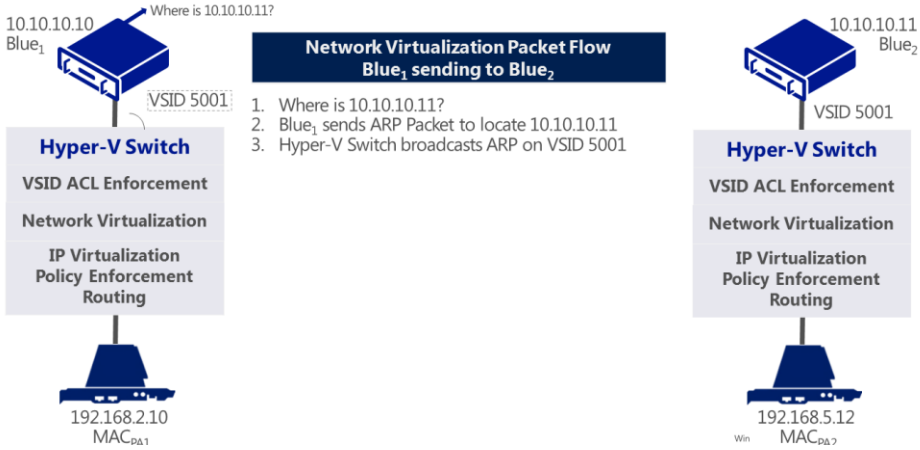

Figure 4: The Hyper-V Switch broadcasts ARP on VSID 5001.

VSID 5001 is a virtual network ID assigned to the BLUE network. Because it's a virtual network ID, the ARP broadcast is sent out on the virtual network only (not over the wire).

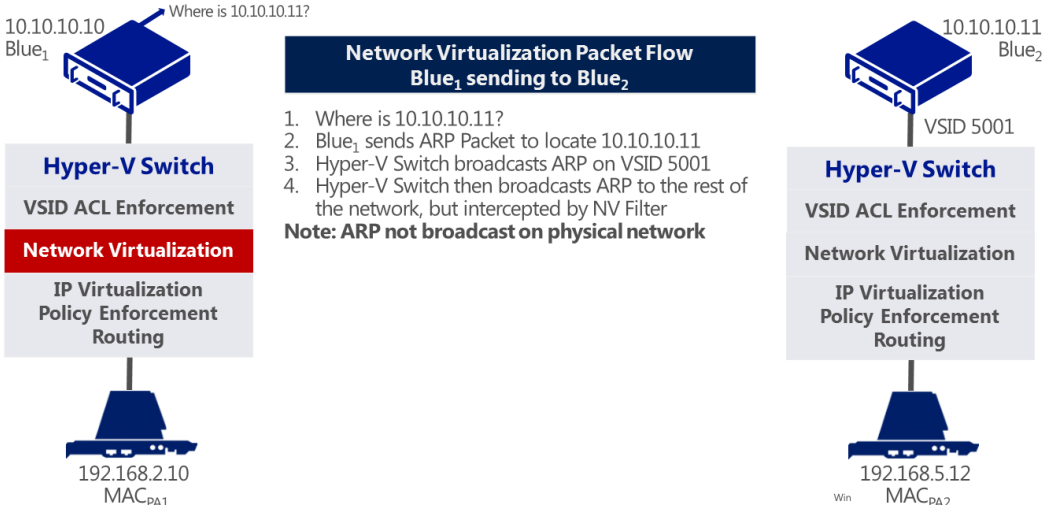

Figure 5: The Hyper-V Switch then broadcasts ARP to the rest of the network, but the packet is intercepted by NV Filter.

The Hyper-V Switch then broadcasts ARP to the rest of the network, but the packet is intercepted by the NV Filter. The NV filter isolates the traffic between Blue1 and Blue2, keeping the broadcast off the physical network.

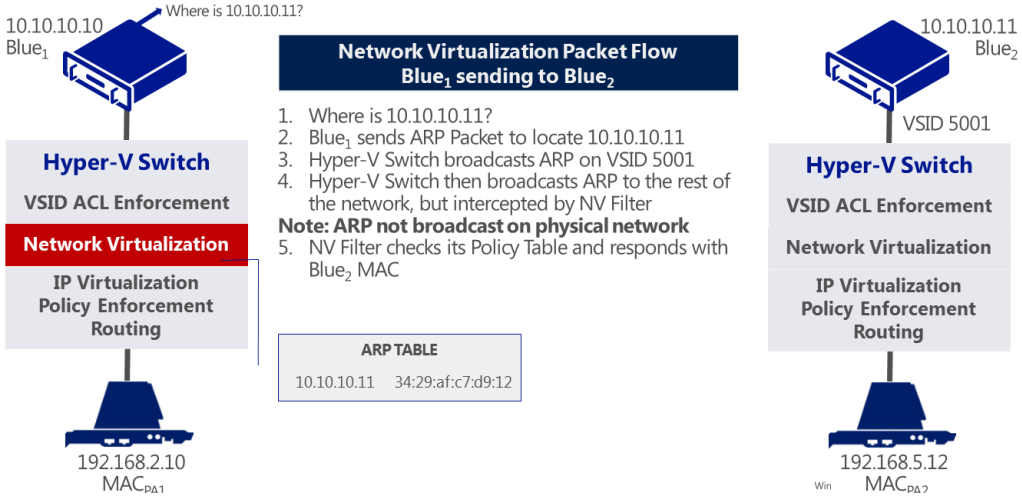

Figure 6: The NV Filter checks its Policy Table and responds with Blue2 MAC.

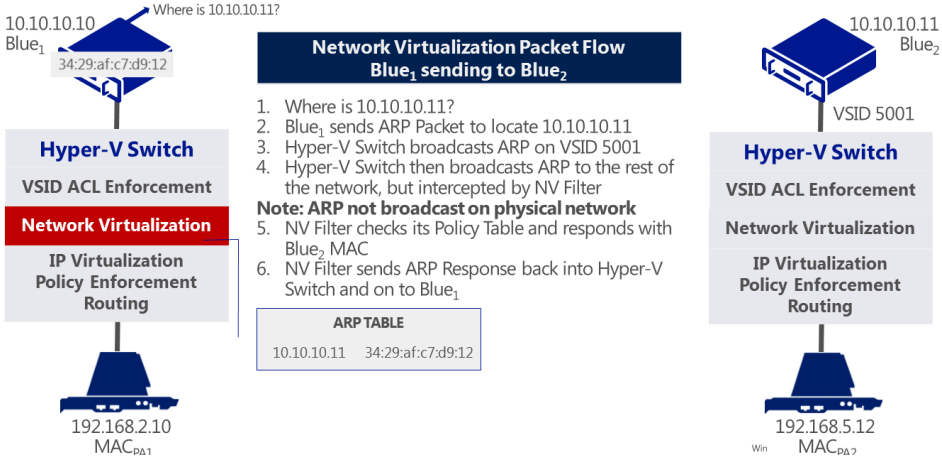

Figure 7: The NV Filter sends the ARP Response back into Hyper-V Switch and on to Blue1.

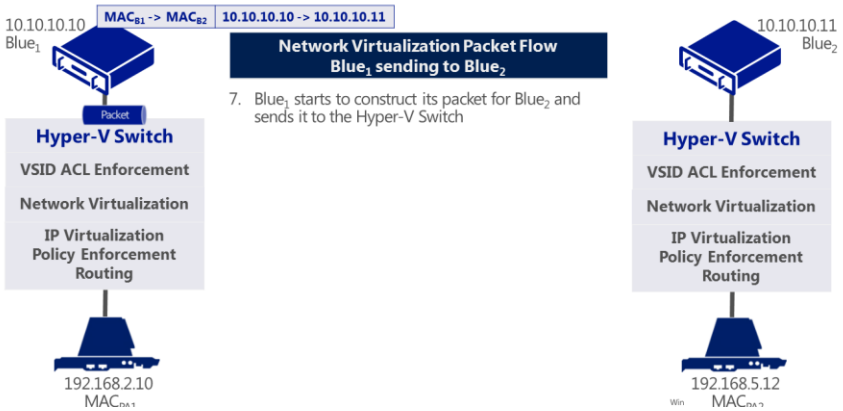

Figure 8: Blue1 constructs the packet for Blue2 and sends it into the Hyper-V Switch.

Figure 9: The Hyper-V Switch attaches the VSID header. NVGRE uses the VSID header to route the packet to the correct virtual network.

Figure 10: The NV Filter checks to see if Blue1 can contact Blue2. A GRE packet is then constructed and sent across the physical network.

Figure 11: The GRE header is stripped off Blue2. The Hyper-V Switch uses the VSID information to send the packet to the Blue2 virtual machine.

With Hyper-V Network Virtualization, customers can now host multi-tenant environments in Hyper-V without changing the underlying physical network infrastructure. Hyper-V Network Virtualization gives network administrators a way to overlay as many logical networks as needed over the top of the physical network infrastructure to provide isolation or extend logical address spaces to remote IP networks and cloud hosters. When you combine Hyper-V Network Virtualization with the power of SCVMM 2012 and partner extensions, you gain the flexibility, automation, and control to operate in any environment, and across hybrid clouds, without changing hardware or investing in new vendor solutions. This technology can be deployed at scale using SCVMM and Hyper-V Network Virtualization gateways such as the Multi-Tenant VPN gateway.

Hyper-V Network Virtualization Benefits

- Easy deployment of virtualized, isolated networks
- Flexible tenant isolation
- Ability to overcome limitations of VLAN's
- Customer IP Address Space can be persisted to the cloud
- End-to-end NVGRE encapsulation with hosters

Hyper-V Extensible Switch

The Hyper-V Extensible Switch is a Layer 2 virtual interface that provides programmatically managed and extensible capabilities to connect virtual machines to the physical network.

Challenges

- Customizing functionality of Hyper-V Switches to meet individual monitoring and management needs
- Better monitoring needed for virtual machine-to-virtual machine traffic
- Better flexibility in existing networks

At a glance: Hyper-V Extensible Switch

- New open framework for adding switch extensions
- Workload-level security
- Full-traffic monitoring tools
- Ability to identify out-of-bound traffic patterns and potential exploits
- Stateful packet inspection
- Windows PowerShell instrumented

Solution

Windows Server 2012 R2 further enhances the Hyper-V Extensible Switch feature introduced with Windows Server 2012. Management features built into the Hyper-V Extensible Switch enable you to manage network traffic as well as troubleshoot and resolve problems on Hyper-V Extensible Switch networks. With the Hyper-V Extensible Switch, extensions are tightly integrated with traffic flow through the virtual switch, enabling a more flexible policy edge (see Figure 12).

The first step towards gaining flexibility in your existing network is to move the policy edge (i.e. the application of ACLs, QoS, isolation and so on) from the physical switch in the network to the virtual switches on the host (where possible). Such a move makes your existing network more consistently manageable and automated with software. A key aspect of the switch is the extensibility, which enables capture extensions (such as InMon's sFlow extension), filter extensions, (such as 5Nine's firewall extension) and forwarding extensions (such as NEC's OpenFlow extension or Cisco's Nexus 1000V extension) to co-exist with each other.

Windows Server 2012 R2 enables firewall-like capabilities in the switch. With extended ACLs, you can apply weighted, stateful rules that enable or deny traffic based on source/destination IP addresses and port numbers. This capability lets you set ACLs not just for a virtual machine, but for workloads running in the virtual machine as well.

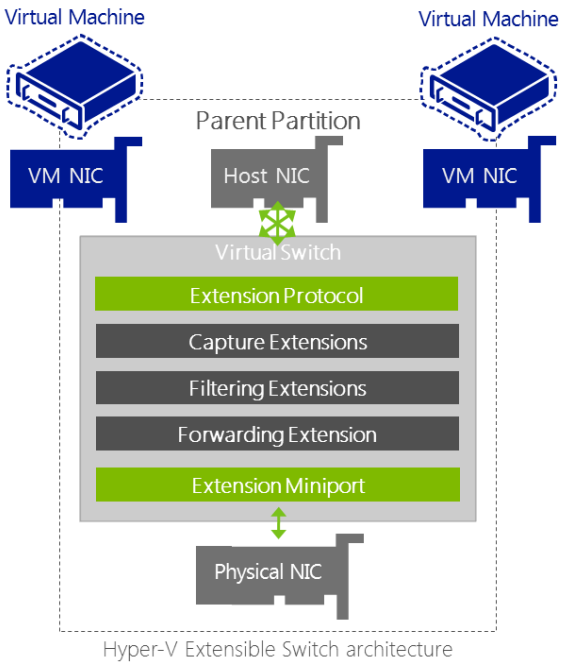

Figure 12: The Hyper-V Extensible Switch tightly integrates extensions with traffic flow through the virtual switch.

Constructing isolated tenant overlays

Once the policy edge is in the virtual switch, you can construct overlays on your existing network to model tenant networking needs. Hyper-V Network Virtualization and System Center 2012 Virtual Machine Manager SP1 provide the ability for tenants to bring their IP addresses to the cloud, with the virtual switches providing isolation amongst tenants.

With the Windows Server 2012 R2 release, you can bring in more of your network topology into the cloud, including your DHCP servers and guest clusters. Hyper-V Network Virtualization now also offers more advanced diagnostics that enable customer-reported networking issues to be quickly isolated down to a problem in the service provider network or the tenant network. Hyper-V Network Virtualization works with NIC Teaming and includes new capabilities (such as task offloads) to drive up performance.

Windows Server 2012 R2 also enables multiple network virtualization protocols to co-exist on the same switch. This capability, called hybrid forwarding, enables Hyper-V Network Virtualization traffic to be natively forwarded by the switch while enabling forwarding extensions (such as the Cisco Nexus 1000V) to forward all other traffic.

Open Framework for adding Extensions

In Windows Server 2012 R2, the Hyper-V Extensible Switch extends virtual switch functionality by providing an open framework for adding switch extensions by enabling management through Windows PowerShell and SCVMM SP1 and above. These switch extensions can be either from Microsoft, internal developers, or from a third-party provider. Common extensions include carrying out packet capture, filtering, or forwarding features. Multiple switch extensions can run simultaneously to provide complex and complimentary packet handing scenarios, such as forwarding incoming packets to another service, filtering out other packet types, and capturing the remainder.

Multi-Tenant VPN Gateway

At a glance: Multi-Tenant VPN Gateway

- Inbox Multi-Tenant NVGRE gateway without having to run separate VPN's
- BGP and NAT for dynamic route updates
- S2S gateway for hosters or enterprises

The Multi-tenant VPN Gateway is a new feature of Windows Server 2012 R2 and System Center 2012 R2 that enables customers and hosters to setup a single gateway for VPN, NAT, and NVGRE connectivity to multiple private clouds, through a single entry point, while still maintaining isolation, even in overlapping Network Address Translation (NAT) and NVGRE networks. Customers running private clouds can use this functionality to extend multiple virtual networks beyond the boundaries of their own datacenter to another private data center or hosted environment such as Windows Azure.

Challenges

- Customers and hosters need a multi-tenant VPN gateway for S2S cloud links that supports NVGRE, isolated NAT, and isolated Border Gateway Protocol (BGP) updates
- Customers need a high-availability gateway device that understands NVGRE traffic and that can encapsulate and decapsulate packets as they leave the datacenter

Solution

- The Windows Server 2012 R2 Multi-Tenant VPN Gateway provides a seamless connection over a S2S VPN link between multiple external organizations and the resources that those organizations own in a hosted cloud. The Multi-Tenant VPN Gateway also enables connectivity between physical and virtual networks, enterprise datacenters, hosting organizations, and enterprise networks and Windows Azure. Guest clustering provides high availability using a hot standby node. A dynamic link library ensures the syncing of any routing configuration from the active node to the hot standby or when the standby becomes active.
- SCVMM 2012 R2 provides templates for customers to deploy these gateways easily and configure them for high availability. You also gain the ability to map VPN networks to virtual networks. To ensure that routes are updated dynamically, Windows Server 2012 R2 implements BGP and incorporates multi-tenant aware NAT for Internet access.
- In general, the Multi-Tenant VPN Gateway works best in the following scenarios:
  - Hoster needs to provide isolated networks for tenant virtual machines with integral S2S VPN and NAT
  - Enterprises have virtualized networks split across different datacenters or virtualized networks (NVGRE-aware) communicating to physical networks (NVGRE-unaware)

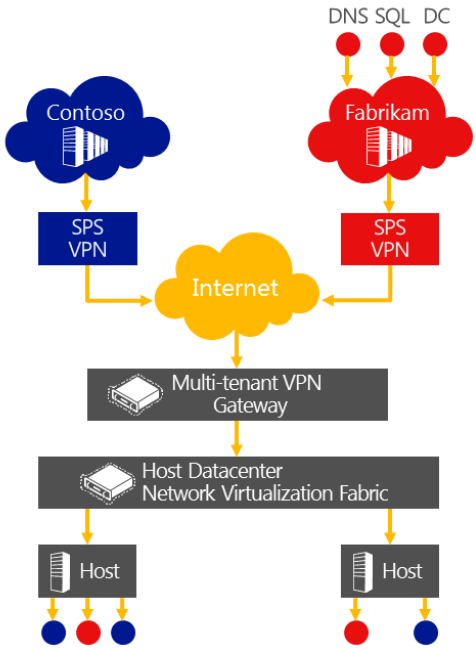

Figure 13: The Windows Server 2012 R2 Multi-Tenant VPN Gateway.

Windows Server gateways enable hybrid connectivity

Frequently, tenants need to communicate outside their network overlay. Windows Server 2012 offered a diverse set of partner gateways that made this possible. With Windows Server 2012 R2, Microsoft supplements its partner offerings with an inbox gateway supporting S2S, NAT, and Forwarding.

The S2S gateway enables tenants to communicate back to their on-premise datacenters (for instance, the web front-end in the public cloud and the SQL back-end in the private cloud). The NAT gateway lets tenants connect to the Internet (or for any scenario requiring address translation). The forwarding gateway lets tenants within a private cloud connect to a shared physical resource (such as storage).

Together with Hyper-V Network Virtualization and the virtual switch, this trifecta of gateways enables the ultimate flexibility in placing and migrating virtual machines and workloads across machines and clouds. Your existing network becomes a pooled resource that can be dynamically managed based on your needs.

Multi-Tenant VPN Gateway Benefits

- You don't have to run separate VPN's for multi-tenant hosting
- Dynamic updating of routes when services or virtual machines are moved with BGP
- Ability to work with any hoster
- You don't need to change private IP address spaces when extending to hosted clouds
- Hosters can support multi-tenant NVGRE environments without having to run a separate VPN appliance and NAT environment for each customer
- The in-box network virtualization gateway doesn't require specialized third-party hardware or software, although you can purchase a hardware-based solution or appliance of choice through a vendor-partner solution

Network Switch Management with OMI

Today, many datacenters run a wide array of heterogeneous devices supplied by different hardware and platform vendors that require different tools and management processes. As a result, companies have been forced to write their own abstraction layer or be locked into a single vendor, which limits their choice and agility.

At a glance: OMI

- Standards-based object model for rapid deployment of logical and physical switch configurations
- Growing partner ecosystem
- Support for multi-vendor network fabric
- Portable and extensible with low overhead
- Extensible DTMT-supported provider model

Challenges

- Multi-vendor device management is difficult
- Companies have to develop their own management tools and abstraction layers
- Development is expensive, heavy, and not very portable

The Open Management Infrastructure (OMI), a DMTF standard for datacenter devices and platform abstractions, offers a highly portable, small footprint, built into the high performance Common Information Model (CIM). OMI can be used to easily compile and implement a standards-based management service into any device or platform. OMI implements its Common Information Model Object Manager (CIMOM) server according to the DMTF management standard. Microsoft is working with Arista and Cisco to port OMI to their network switches for Windows Azure and cloud datacenters. IT needs this type of abstraction layer for easy configuration and management of its logical and physical network infrastructure as well as the physical platforms and appliances that support them. Partners that adopt OMI can gain the following:

- **DMTF Standards Support:** OMI implements its CIMOM server according to the DMTF standard
- **Small System Support:** OMI can also be implemented in small systems (including embedded and mobile systems)
- **Easy Implementation:** OMI offers a greatly shortened path to implementing WS-Management and CIM in your devices/platforms
- **Remote Manageability:** OMI provides instant remote manageability from Windows and non-Windows clients and servers as well as other WS-Management-enabled platforms
- **API compatibility with Windows Management Instrumentation (WMI):** Providers and management applications can be written on Linux and Windows by using the same APIs
- **Support for CIM IDE:** OMI offers tools for generating and developing CIM providers such as Visual Studio's CIM IDE
- **Optional Windows PowerShell Support:** If OMI providers use a set of documented conventions, Windows PowerShell discovers and auto-generates cmdlets from them (This is how many of the 2300+ cmdlets in Windows Server 2012 are implemented)

For developers, OMI's small footprint (250KB base size with a working set memory usage of 1 megabyte (MB)) and high-quality code help reduce the complexity of developing a high performance, stable standards-based management stack. For IT pros, OMI greatly amplifies your effectiveness and productivity by increasing the number and types of devices you can manage and by unifying the management experience with standard-based management and automation tools, such as Windows PowerShell, System Center, and other management solutions.

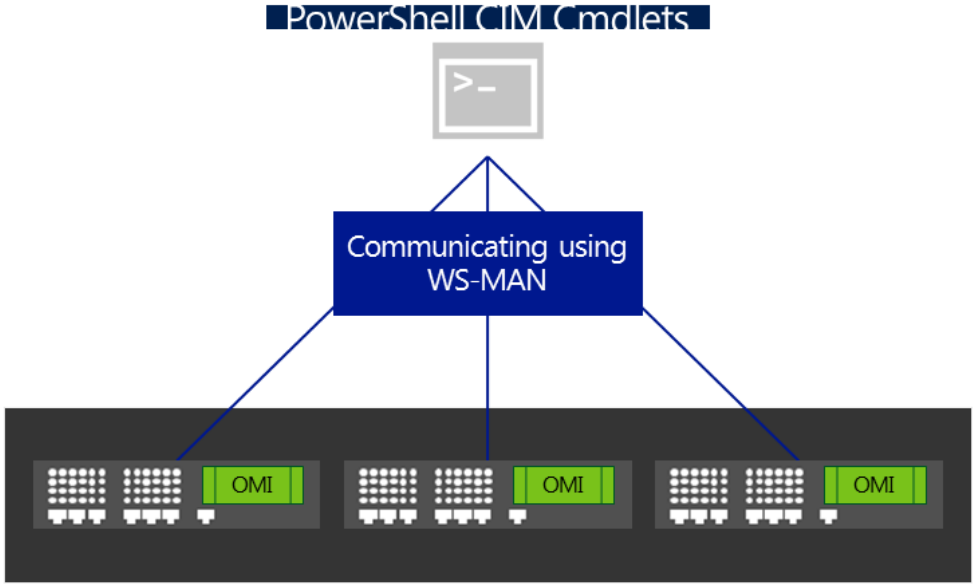

Figure 14: OMI implementation of a CIM server.

Physical switch management in Windows Server 2012 R2 with Windows PowerShell

In Windows Server 2012 R2, you can use Windows PowerShell to deploy your physical network. This functionality helps automate the setup of your network (such as configuring switch ports, setting VLANs, and so on) that works consistently across vendors. Microsoft worked closely with major industry partners to introduce a new standards-based switch management schema. In the future, look for logo stamps on switches that implement this industry standard.

In addition, Windows Server 2012 R2 addresses specific customer scenarios through SCVMM 2012 R2. One of the major pain points customers have is matching the VLAN configuration across the physical switch and the virtual switch. SCVMM 2012 R2 monitors the VLAN configuration across both switches, notifying the admin if something in the VLAN configuration is out of sync. This functionality enables the administrator to easily fix the misconfiguration.

Extensibility

OMI uses a provider model to enable developers to extend OMI to their specific device or platform. Historically, providers have been very hard to write, which made them costly and unstable. OMI utilizes a greatly simplified provider model used by WMI in Windows Server 2012 and Windows 8 that helps standardize management of datacenter devices including both synthetic and hardware switches to support software configurations on virtualized networks.

OMI Benefits

- Gives datacenters and clouds a standards-based object model for rapid deployment of logical and physical switch configurations
- Simplifies multi-vendor device management
- Offers WMI and CIM object model, with Visual Studio Integrated Development Environment (IDE)
- Is embraced by Cisco, Arista, HP,

Partner Ecosystem for Software Defined Networking

Microsoft has been very busy developing partner and vendor solutions that extend and enhance the rich feature set of Windows Server 2012 R2 networking. The primary areas of partner integration are:

Gateway appliances

Network virtualization gateways are appliances that integrate with and extend the scalability of Microsoft network virtualization technologies including multi-tenant NVGRE routing and isolation. These appliances make it easy for customers to move workloads to Infrastructure as a Service (IaaS) clouds and add efficiency for hosters and datacenter administrators to manage their multi-tenant infrastructure with a single appliance. For example, HUAWEI is developing a high-performance HNV gateway for Window Server 2012 R2.

The following vendors are developing network virtualization gateway appliances for Windows Server 2012 R2:

- F5 Networks
- Iron Networks
- HUAWEI

OMI-based switch solutions

The growth of cloud-based computing is driving demand for more automation. Automation requires a solid foundation built upon management standards. Arista has been developing, in close collaboration with Microsoft, OMI-based switch management layers in the Windows Azure datacenters around the world. OMI uses the DMTF CIM object model and protocol to manage servers and network switches. More information about CIM may be found at DMTF (http://www.dmtf.org).

Figure 15: Microsoft partner ecosystem for SDN.

Hyper-V Switch extensions

Hyper-V Switch Extensions provide a comprehensive and extensible architectural platform for virtual machine and cloud networking. An example of this is the Cisco Nexus series of switches. The vendor-supplied extensions accelerate server virtualization and multi-tenant cloud deployments in a secure and operationally transparent manner. These solutions integrate into the Windows Server 2012 and Windows Server 2012 R2 Extensible Switch and are fully compatible with SCVMM 2012 SP1.

The following vendors provide addition functionality on their switch infrastructure with Hyper-V Switch extensions:

- Cisco
- NEC
- 5Nine Software
- InMon

Chipset extensions

Chipset extensions are driver-based enhancements that further the capabilities of host bus adapters (HBAs), Fibre-channel adapters, NICs, and other devices that improve scale, manageability, or performance when run on the Windows Server 2012 or Windows Server 2012 R2. For example, Mellanox RDMA technology for InfiniBand running Windows Server 2012 Hyper-V set new speed records for SMB-Direct by achieving a 10.36 GBPS/sec throughput while consuming only 4.6 percent CPU overhead.

The following vendors offer chipset extensions for various hardware and devices:

- Broadcom
- Intel
- Mellanox Technologies
- Emulex
- Brocade

SDN Benefits Summary

As discussed throughout this section, SDN enables software to dynamically manage the network in a way that helps you meet the requirements of your applications and workloads. With server virtualization, you are able to decouple a compute instance from the underlying hardware. This capability enables you to pool compute resources for greater flexibility. However, to truly transform your datacenter to a cloud-enabled facility, you've also got to deliver your storage, compute, and networking resources as a shared, elastic resource pool for on-demand delivery of datacenter capacity. This datacenter-level abstraction is a key part of the Microsoft "Cloud OS Vision."

Windows Server 2012 introduced Hyper-V Network Virtualization. To ensure that you can carry forward your existing investments, Windows Server 2012 R2 virtual network support offers even more control and management by setting up on existing networking gear and being compatible with VLANs. Because of this functionality, virtual networks can scale much better than VLANs for your private and hybrid cloud environments.

Windows Server 2012 R2 and SCVMM 2012 R2 combine to give you network virtualization at scale with the ability to centrally define and control policies that govern both physical and virtual networks, including traffic flow between them. New gateway services provide a pain-free way to extend NVGRE packet environments to external hosters. The ability to implement these network policies in a consistent manner, at-scale, even as new workloads are deployed or moved, provides a big benefit to customers.

As always, Microsoft remains committed to standards-based management frameworks. Arista Networks announced full support for the OMI technology across all Arista platforms through the Arista Extensible Operating System (EOS) software. This support helps enable datacenter plug-n-play so that devices "just work". Specifically, this will simplify provisioning and configuration of top-of-rack switches using Windows Server 2012 R2 and System Center 2012 R2.

Networking solutions that deliver continuous application availability

- DHCP Failover

Network Fault Tolerance with SMB Multichannel

Hardware and software failures happen. CA provides the services that automatically detect and protect against such failures. Such reliability applies to mission-critical applications and the network services (virtualized or not) that they depend on. Windows Server 2012 R2 offers new and enhanced features that help protect against network path and NIC failures while offering infrastructure service resiliency. Some of these features include the following:

- SMB Multi-Channel
- Network QoS

At a glance: SMB Multichannel

- Multiple network paths can be aggregated for SMB sessions
- Transparent Load Balancing and Failover (LBFO)
- Aggregated bandwidth for improved performance

- NIC Teaming
- Dynamic NIC Teaming

Challenges

- SMB sessions need to be fault tolerant to prevent path failures from affecting application availability
- SMB sessions need to be able to take advantage of multiple paths for aggregation

Solution

Windows Server 2012 introduced a new feature called SMB Multichannel, part of the SMB 3.0 protocol. SMB Multichannel increased the network performance and availability for file servers, enabling file servers to use multiple network connections simultaneously. Other capabilities include the following:

- Increased throughput
  - The file server can simultaneously transmit more data using multiple connections for high-speed network adapters or multiple network adapters
- Network fault tolerance
  - When using multiple network connections at the same time, the clients can continue to work uninterrupted despite the loss of a network connection

- Automatic configuration
    - SMB Multichannel automatically discovers the existence of multiple available network paths and dynamically adds connections as required.

Fault tolerant application shares continue to work without any disruption in service if there is a path failure between the client and the server. A bi-product of this capability is load balancing across all paths of the aggregated bandwidth to CA SMB shares, thus delivering better throughput. SMB Multichannel setup is automatic or Windows PowerShell instrumented for Windows 8 and Windows Server 2012 and higher operating systems.

With SMB Multichannel, network path failures are automatically and transparently handled without application service disruption. Windows Server 2012 R2 now scans, isolates, and responds to unexpected server problems that enable network fault tolerance (if multiple paths are available between the SMB client and the SMB server). SMB Multichannel also provides aggregation of network bandwidth from multiple network interfaces when multiple paths exist. Server applications can then take full advantage of all available network bandwidth, becoming more resilient to a network failure.

SMB Multichannel Benefits

- Increased throughput for SMB workloads
- Transparent LBFO
- Auto-configuration for Windows 8 / Windows Server 2012 and higher
- Support for Tier 1 server workloads

Highly Available DHCP Service

In the past, customers and datacenters have relied on DHCP services to manage the issuance of DHCP scope addresses and options. However, applying a fault-tolerant solution has often proven difficult.

At a glance: DHCP Failover

- DCHP Servers replicate scope information to a partner server
- Load sharing and fault tolerant modes
- Scope level replication (hub and spoke topology supported)
- Automatic detection and convergence of scope data

Challenges

- DHCP fault tolerance
- DHCP high availability

Some administrators choose to use split scopes, meaning that two DHCP servers run separate scopes within the same group of subnets. The drawback of this approach is that if one DCHP server fails, only a percentage of the addresses are available. That's because the full set of addresses get divided between the two servers. In Windows Server 2003 clustering, an administrator could set up a DHCP service in a high-availability cluster. This capability forced centralized management of DHCP servers, causing the customer to incur the cost and management overhead of a Windows Failover Cluster.

Windows Server 2012 R2 DHCP Failover

DHCP Server Failover in Windows Server 2012 R2 enables two DHCP servers to synchronize lease information almost instantaneously, providing high availability of DHCP service. If one of the servers becomes unavailable, the other server assumes responsibility for servicing clients for the same subnet. You can also configure failover with load balancing, with client requests distributed between the two DHCP servers.

DHCP Server Failover provides support for two DHCPv4 servers. Administrators can deploy Windows Server 2012 R2 DHCP servers as failover partners in either hot standby mode or load-sharing mode.

Hot standby mode

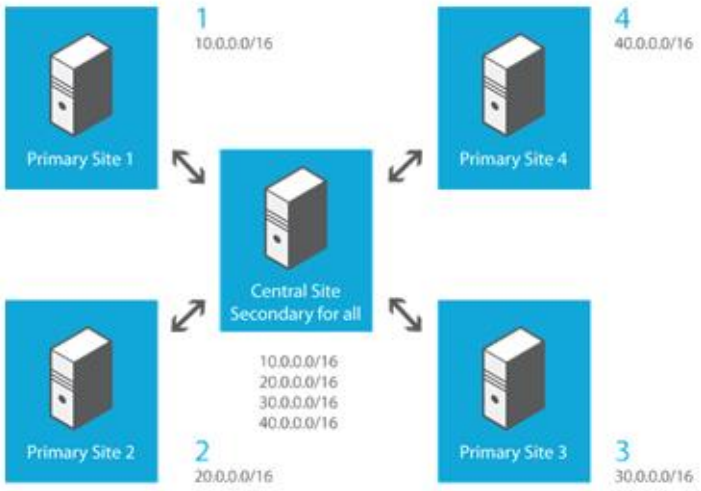

Figure 16: DHCP Server Failover in hot standby mode.

In hot standby mode, two servers operate in a failover relationship in which an active server leases IP addresses and configuration information to all clients in a scope or subnet. The secondary server is a warm standby and kept in sync with all scope data including active leases. If the secondary server loses network communication with the primary server, the failover occurs automatically, reversing the server roles. When the primary server comes back up, it becomes secondary, remaining fully synchronized.

The two DHCP servers in a failover relationship do not themselves need to be on the same subnet because scope replication is done over TCI/IP. Client access to DHCP services from the required subnets is accomplished by using a DHCP Relay agent or appliance (the same as in earlier Windows Server versions).

The secondary server assumes this responsibility if the primary server becomes unavailable. A server is primary or secondary in the context of a subnet, so a server that is primary for one subnet could be secondary for another. A hub and spoke topology is common. This topology is where one server in a central location handles secondary scope responsibilities for all scopes in all sites. Again, failover can be done at a scope or server level (all scopes on the server).

The hot standby mode of operation is best suited to deployments in which a central office or datacenter server acts as a standby backup server to a server at a remote site that is local to the DHCP clients. In this hub-and-spoke deployment, it is undesirable to have a remote standby server service clients unless the local DHCP server becomes unavailable.

Load-sharing mode

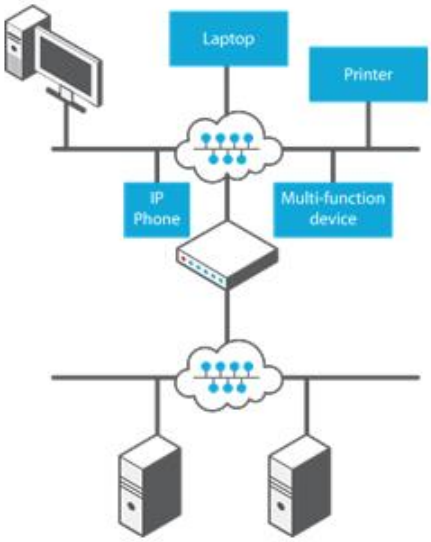

Figure 17: DHCP Server Failover in load-sharing mode.

In load-sharing mode, the default mode, the two servers simultaneously serve IP addresses and options to clients on a particular subnet. As previously mentioned, the two DHCP servers in a failover relationship do not need to be on the same subnet. Client requests are load balanced and shared between the two servers. This mode is best suited to deployments in which both servers in a failover relationship are located at the same physical site. Both servers respond to DHCP client requests based on the load distribution ratio configured by the administrator.

DHCP Failover Benefits

- Automatic DHCP failover based on DHCP failover Internet Engineering Task Force (IETF) spec
- Elimination of single point of failure
- Inbox and multi-site supported
- Active/active or active/passive

Predictable performance with Quality of Service

Whether you use purpose-built or industry-standard storage solutions, having the right management and backup capabilities can help you better manage your storage capacity for a single server or multiple servers.

At a glance: Network QoS

- A safeguard against a virtual machine(s) taking all available bandwidth
- Maximum and minimum bandwidth with Priority Tagging
- SCVMM-supported for large scale
- Policy-driven for simple deployment

Challenge

Customers and datacenters need to be able to set minimum and maximum bandwidth levels for virtual machines.

Solution

Storage QoS, a new quality-of-service feature in Windows Server 2012 R2, enables you to restrict disk throughput for overactive or disruptive virtual machines. For maximum bandwidth applications, Storage QoS provides strict policies to throttle IO to a given virtual machine to a maximum IO threshold. For minimum bandwidth applications, Storage QoS provides policies for threshold warnings that alert an IO-starved virtual machine when the bandwidth does not meet the minimum threshold.

You can manage Network QoS policies and settings dynamically with SCVMM 2012 R2 and Windows PowerShell while the virtual machine is running. The new QoS cmdlets support the QoS functionalities available in Windows Server 2008 R2, such as maximum bandwidth and priority tagging, and the new features available in Windows Server 2012, such as guaranteeing that the minimum amount of required bandwidth for a given type of network traffic flow is always available.

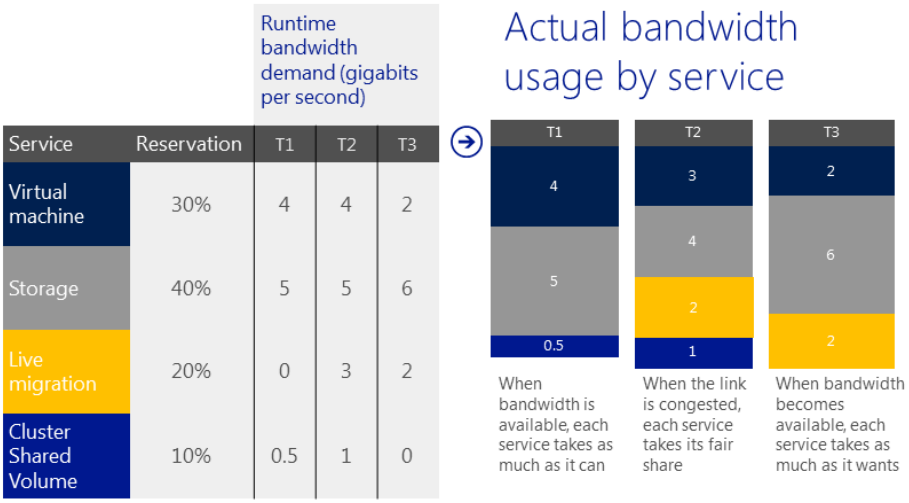

Figure 18: How relative minimum bandwidth works for different network flows.

Figure 18 shows how relative minimum bandwidth works for each of the four types of network traffic flows in three different time-periods (T1, T2, and T3). The table on the left illustrates the configuration of the minimum amount of required bandwidth a given type of network traffic flow needs. For example, storage must have at least 40 percent of the bandwidth (4 Gbps of a 10-GbE network adapter) at any time. The table on the right shows the actual amount of bandwidth each type of network traffic has in T1, T2, and T3. In this example, storage is actually sent at 5 Gbps, 4 Gbps, and 6 Gbps, respectively, in the three periods.

QoS minimum bandwidth benefits vary from public cloud hosting providers to enterprises. Most hosting providers and enterprises today use a dedicated network adapter and a dedicated network for a specific type of workloads such as storage or live migration to help achieve network performance isolation on a server running Hyper-V

Benefits for public cloud hosting providers

- Enables customer hosting on a server running Hyper-V while still providing a certain level of performance based on SLAs.
- Helps ensure that customers won't be affected or compromised by other customers on their shared infrastructure, which includes computing, storage, and network resources.

Benefits for enterprises

- Runs multiple application servers on a server running Hyper-V. Each application server delivers predictable performance, eliminating the fear of virtualization due to lack of performance predictability.
- Virtualizes busy SQL databases and ensures that they get the bandwidth they need.
- Sandboxes applications and provides different SLAs/pricing depending on bandwidth guarantees (applies to customers and hosters).

Benefits for customer's SLA compliancy

- Helps guarantee predictable network performance and fair sharing during congestion.
- Supports bandwidth floors and bandwidth caps.
- Helps enforce customer SLAs and maximum pricing caps.
- Sets QoS for virtual machine(s) or traffic type.
- Uses software built into Windows Server 2012 R2 or hardware capable of Data Center Bridging (DCB) to assign minimum QoS settings.
- Supports dynamic change of QoS settings through Windows PowerShell without any downtime.

NIC Teaming

Windows Server 2012 introduced in-box NIC teaming. NIC Teaming provides fault tolerance on your network adapters by enabling multiple network interfaces to work together as a team, preventing connectivity loss if one network adapter fails.

At a glance: NIC Teaming

- Inbox LBFO support
- Vendor and switch independent
- Support for up to 32 NIC's
- Supported in virtual machine and host
- Dynamic Flow control within

Challenges

- LBFO solutions can be vendor-centric, switch dependent, and susceptible to driver update failure
- Inability to take advantage of existing NIC's that ship with servers for LBFO

Solution

Customers need a way to provide LBFO out-of-the-box without relying on expensive vendor-centric solutions. NIC Teaming in Windows Server 2012 R2 enables multiple network interfaces to work together as a team, preventing connectivity loss if one network adapter fails. This feature also enables you to aggregate bandwidth from multiple network adapters. For example, four 1 GB network adapters can provide an aggregate of 4 GB of throughput. In Windows Server 2012 R2, the load-balancing algorithms have been further enhanced with the goal to better utilize all NICs in the team, significantly improving performance.

The advantages of a Windows teaming solution are that it works with all network adapter vendors, spares you from most potential problems that proprietary solutions cause, provides a common set of management tools for all adapter types, and is fully supported by Microsoft.

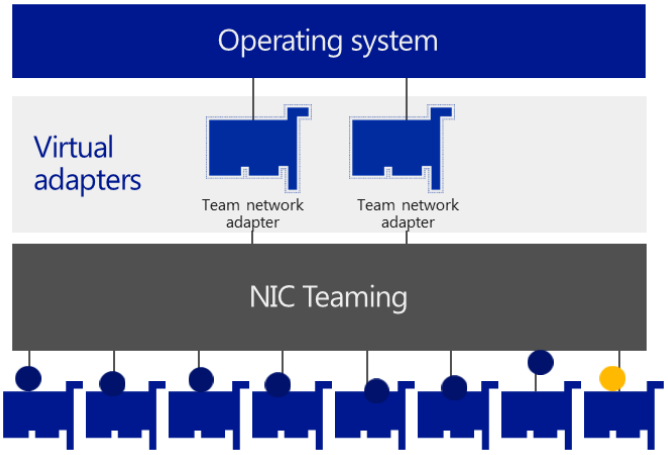

Figure 19: NIC Teaming.

Dynamic NIC Teaming

Inbox NIC Teaming remains one of Windows Server 2012 most popular features. At the same time, customers pointed out that load distribution algorithms were not working optimally for scenarios where there were a few large flows. Since NIC Teaming affinitized a flow to a NIC, a few large flows could overwhelm the NIC even if there was spare capacity available in the team.

Windows Server 2012 R2 breaks up a flow into smaller flow-lets based on natural gaps that occur in a TCP stream and load balances flow-lets to NICs. The result is optimal utilization of the NIC team across any kind and any number of flows.

LBFO maximizes resource utilization within NIC teams by balancing network traffic across all team members. This mechanism is ideal when there are fewer virtual machines per team, thus reducing traffic redirection. LBFO works by monitoring the traffic distribution within the team and adjusting the flow to team members automatically.

NIC Teaming Benefits

- Inbox network LBFO
- Vendor neutral and switch independent
- Local or remote management through Windows PowerShell or Server Manager UI
- Enhanced in Windows Server 2012 R2 for better flow control in the team

High-performance networking with current and next-generation hardware

Customers want to get the best performance out of their hardware, regardless of whether they are using industry-standard hardware or high-end hardware. Some of the more common challenges they encounter include the following:

- Limitations in network bandwidth
- Limitations in processing power

Windows Server 2012 R2 addresses these issues with the following features:

- Virtual Receive Side Scaling (vRSS)
- Single Root IO Virtualization (SR-IOV)
- SMB Direct (RDMA)
- Dynamic VMQ

SMB Direct and RDMA

The SMB protocol in Windows Server 2012 and R2 includes support for RDMA network adapters, which enables storage performance capabilities that rival Fibre Channel. RDMA network adapters operate at full speed with very low latency due to the ability to bypass the kernel and perform write and read operations directly to and from memory. This capability is possible since reliable transport protocols are implemented on the adapter hardware, enabling zero-copy networking with kernel bypass.

At a glance: SMB Direct

- SMB Direct implements RDMA
- SMB Direct enables higher performance by providing direct transfer of data from a storage location to an application

Challenges

- With 10 and 40 GB NICs becoming the new normal, network channel performance can be limited by how fast the CPU can handle traffic as opposed to the line rate of the NIC
- Offloading data transfer to the underlying hardware

Solution

SMB Direct implements RDMA, enabling applications such as SMB to perform data transfers directly from memory, through the adapter, to the network, and then to the memory of the application requesting data from the file share. This capability is especially useful for read/write intensive workloads such as Hyper-V or SQL Server, often resulting in remote file server performance comparable to local storage.

In traditional networking, a request from an application to a remote storage location must go through numerous stages and buffers on both the client and server side, such as the SMB client or server buffers, the transport protocol drivers in the networking stack, and the network card drivers.

With SMB Direct, the application makes a data transfer request straight from the SMB client buffer, through the client NIC to the server NIC, and up to the SMB server.

The following provides an example of a solution without SMB-Direct RDMA and one that works with it:

Without SMB Direct and RDMA

1. A client application makes a request for 500K of data. This can be a client-to-server request or a server-to-server request (as with scale-out shares for Hyper-V storage).
2. The client formulates the SMB request and sends it over the TCP/IP stack to the server.
3. The server processes the 500K of data into packets. This procedure takes up CPU cycles on the server.
4. The client receives the packets and assimilates them back into the original 500k of data, then sends them to the stack. This procedure takes up CPU cycles on the client.

Note: The server cannot send the entire 500k at once because the data must be broken down into smaller packets.

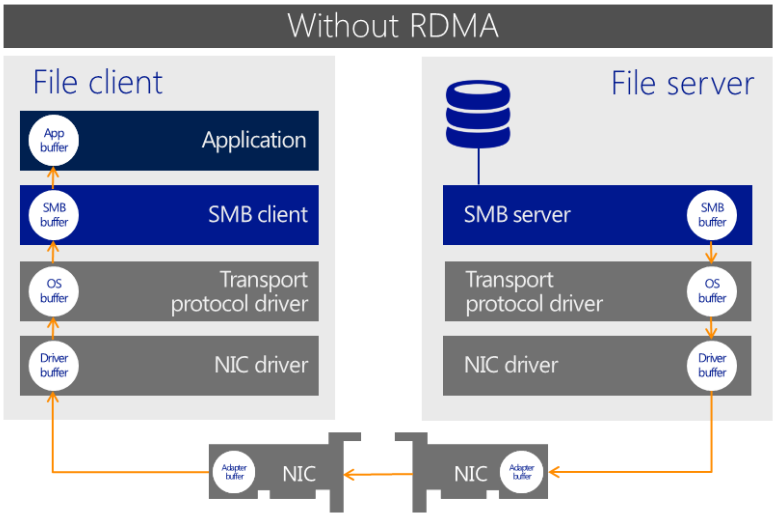

Figure 20: A client and server example without SMB Direct and RDMA.

When using multiple NICs to handle many IO intensive operations, the CPU can become bottlenecked while repeatedly performing the kernel mode activity. The more CPU time that is spent on processing network packets, the less CPU time is available for other tasks such as database requests and virtual machine workloads.

With SMB Direct and RDMA

Through work with partners and vendors, Microsoft has brought to Windows Server 2012 R2 a class of specialized NICs to support high-speed data transfers. These NICs have a better CPU and support RDMA so that they can transfer data without involving the host CPU.

In the SMB Direct RDMA example below:

1. The client requests 500K of data.
2. The SMB-Direct transport driver locates a place in memory where that data should reside and registers it on behalf of the NIC.
3. An RDMA request is sent to the server requesting to read the 500K of data directly in client memory.
4. The client application and server transfer data directly, memory-to-memory, outside the packet level constraints incurred when normal peer-to-peer networking happens over TCP/IP.
5. The two NIC or teams perform the transfer without any outside CPU dependencies and overhead.

SMB Direct is extremely fast and delivers speeds comparable to that of local storage. Support for InfiniBand, RoCE, and iWARP network interfaces also helps further increase speed.

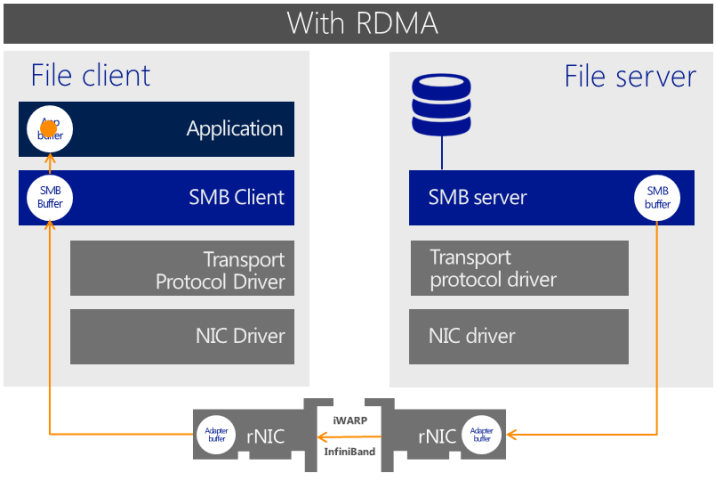

Figure 21: A client and server example with SMB Direct and RDMA.

In traditional networking, a request from an application to a remote storage location must go through numerous stages and buffers on both the client and server side, such as the SMB client or server buffers, the transport protocol drivers in the networking stack, and the network card drivers.

With SMB Direct, the application makes a data transfer request straight from the SMB client buffer, through the client NIC to the server NIC, and over to the SMB server. This change provides the application with access to remote storage at the same speed as local storage.

With iWarp and InfiniBand networking technologies, this change can deliver transfer rates equivalent to 50Gbps on a single 56 GB NIC. SMB Direct can enhance transfer rates and increase the reliability of network paths through direct compatibility with SMB Multichannel as part of SMB 3.0.

Did you know?

- Mellanox and Intel are some of the vendors that make RDMA-capable NICs
- RDMA will become defacto in 10GB and 40GB NICs

SMB Direct and RDMA Benefits

- Higher performance and lower latency through CPU offloading
- High-speed network utilization (including InfiniBand and iWARP)
- Remote storage at the speed of direct storage
- Transfer rate of approximately 50 Gbps on a single NIC port
- Compatibility with SMB Multichannel for LBFO

Virtual Receive Side Scaling (vRSS)

Windows Server 2012 first introduced Receive Side Scaling (RSS) as a way to spread the CPU load of processing network IO across all available CPUs. This was available for the host, but not the virtual machines running on that host.

Challenges

RSS capabilities need to be made available on a virtual machine and the Hyper-V host.

Solution

Windows Server 2012 R2 introduces vRSS, a feature that makes RSS available to the host and the virtual machines on that host. vRSS enables both the host and the virtual machine to use multiple cores, resulting in bandwidth scaling characteristics similar to what RSS enables for large physical workloads. This change substantially increases the networking capabilities of virtual machines on a host by eliminating multiple bottlenecks and enabling use of all resources available to the virtual machine. vRSS gives near-line rate speeds to the Hyper-V host and virtual machine, using existing hardware to help exceed the current limitation of approximately 4.5Gbs experienced with a 10Gb NIC connected to a virtual machine. In test environments with a simulated workload, vRSS enabled a virtual machine to meet a near line rate on a 10Gbps NIC compared to ~5.5Gbps without this capability.

vRSS works by scaling a virtual machine's receive-side traffic to multiple virtual processors, so that the incoming traffic spreads over the total number of cores available to that virtual machine. With vRSS, send-side traffic from a virtual machine is also distributed over multiple processors, so that virtual switch processing does not generate bottlenecks on a single physical processor when sending large amounts of outgoing traffic. This capability is possible with any NICs that support SR-IOV RSS.

vRSS Customer Benefits

- vRSS improves virtual machine performance by spreading the network IO processing overhead across multiple virtual processors
- Near-line rate network speed for a virtual machine on existing hardware
- Excellent performance on network intensive virtual machines
- Up to 100 Gbps speed for a virtual machine

Dynamic Virtual Machine Queue (VMQ)

Without VMQ, the Hyper-V virtual switch handles routing and sorting packets inbound to virtual machines. This responsibility can lead to a lot of CPU processing for the virtual switch on heavily-loaded Hyper-V hosts. As a result, a majority of the network processing can burden CPU0 and limit the scale of the solution.

Challenge

CPU pressure on the Hyper-V Virtual Switch due to CPU0 affinity in Windows Server 2012.

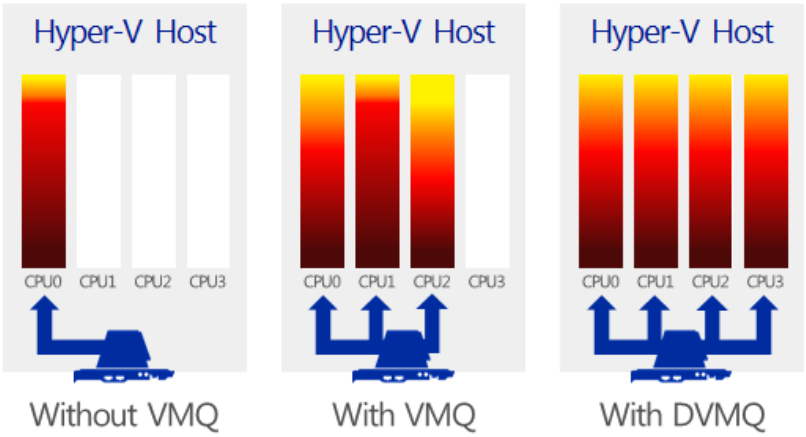

Figure 22: Different models with and without VMQ.

With VMQ

With VMQ, load balancing CPU power moves down into the network card. In the silicon, queues are created for the virtual machine NICs for processing the routing and sorting of media access control (MAC) addresses and VLAN tags. Processor cores are dynamically allocated to the queues and can recruit and release processors based on the network load. This capability results in better processor use for adaptive network workloads.

With Dynamic VMQ

With Dynamic VMQ, you can dynamically allocate processor cores for a better spread of network traffic processing. As a result, you can make better use of multi-core server hardware by distributing the handling of incoming virtual switch requests workload across multiple processors. This capability improves performance in situations where processor pressure on CPU0 causes network latency of a virtual switch.

Virtual Machine Queue Benefits

- Better network performance of virtual machines
- More efficient handling of heavy-network volume virtual machines

Single Root I/O Virtualization (SR-IOV)

SR-IOV is an open standard introduced by the Peripheral Component Interconnect Special Interest Group (PCI-SIG) that owns and manages PCI specifications. SR-IOV works in conjunction with system chipset support for virtualization technologies that provide remapping of interrupts and Direct Memory Access. SR-IOV also enables assignment of SR-IOV-capable devices directly to a virtual machine.

Challenges

- Virtual machine workloads cannot achieve true line speeds of the host NICs due to CPU overhead of processing NIC interrupts and DMA requests
- Heavy Hyper-V virtual switch activity can drive up CPU utilization on the host

SR-IOV maps virtual network functions from the NIC directly to the virtual machine, bypassing the Hyper-V Switch.

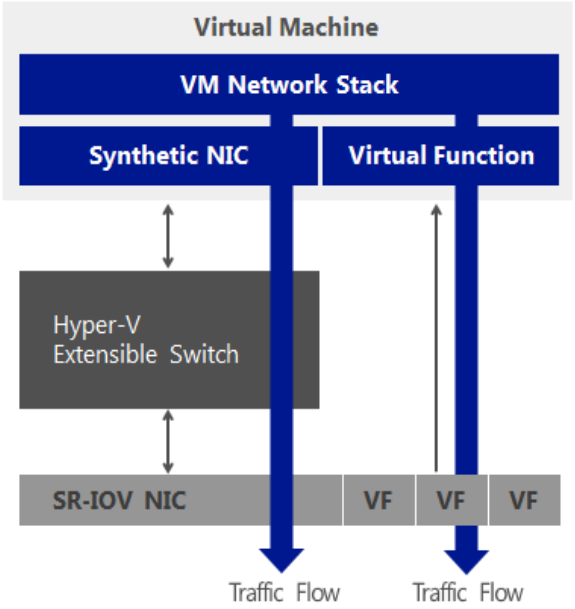

Figure 23: SR-IOV maps virtual network functions from the NIC directly to the virtual machine.

Hyper-V in Windows Server 2012 R2 enables support for SR-IOV-capable network devices and a SR-IOV virtual function of a physical network adapter to be assigned directly to a virtual machine. This configuration increases network throughput and reduces network latency and the host CPU overhead required for processing network traffic. These new features enable enterprises to take full advantage of the largest available host systems to deploy mission-critical, tier-1 business applications with large, demanding workloads. You can configure your systems to maximize the use of host system processors and memory to effectively handle the most demanding workloads.

SR-IOV Benefits

- Maximizes use of host system processors and memory
- Reduces host CPU overhead for processing network traffic (by up to 50 percent)
- Reduces network latency (by up to 50 percent)

High-performance networking with current and next-generation hardware

Manageability is one of the most important challenges businesses face. There are many types of management features that can help IT staffs simplify their lives. For example, having the ability to automate regular tasks or control the entire IP address infrastructure, no matter the size of your organization. There's also having the ability to maximize performance on a multi-site environment or track resource usage and build chargeback/show-back solutions.

Windows Server 2012 R2 greatly enhances manageability of enterprise network resources and assets with tools and features such as the following:

- IP Address Management (IPAM)
- Resource Metering
- Network monitoring using System Center 2012 Operations Manager
- Management with SCVMM 2012
- Windows PowerShell

Windows Server 2012 R2 IP Address Management (IPAM)

Windows Server 2012 R2 builds on the networking advances in Windows Server 2012 with an array of new and enhanced features that help reduce networking complexity while lowering costs and simplifying management tasks. With Windows Server 2012 R2, you now have the tools to automate and consolidate networking processes and resources.

At a glance: Windows Server 2012 R2 IPAM

- Enterprise-level IP address space
- Enterprise-level infrastructure management and monitoring
- Support for a centralized or distributed model
- Manual or automatic discovery of DHCP, DNS, and domain controllers
- Physical and virtual address space and integration with SCVMM
- Integration with SCVMM network configuration and deployment
- Active Directory site integration for large scale role-based access and control

Challenges

- Difficulties with centralized management of IP address space
- Difficulties with virtualized networks
- High overhead resulting from manual, DCHP, and DNS administration where each client has its own services

Solution

Windows Server 2012 introduced IPAM, which provides centralized tracking and administration of IP addresses (physical and virtual), DHCP, and DNS, along with rich Windows PowerShell automation. In Windows Server 2012 R2, IPAM enables network administrators to fully streamline IP address space administration of both physical (fabric) and virtual (tenant) networks. The integration between IPAM and SCVMM 2012 R2 provides end-to-end IP address space automation for Microsoft-powered cloud networks. A single instance of IPAM can detect and prevent IP address space conflicts, duplicates, and overlaps across multiple instances of SCVMM 2012 R2 deployed in a large datacenter or across datacenters.

Fine-grained administrative control

As customer clouds grow in size and deployment, there is a need for IPAM to enable appropriate privileges for the different scopes. With the R2 release, IPAM can now enable granular role-based access control (RBAC) and delegated administration. System and network administrators can use IPAM to define the roles (collection of administrative operations and whether they can be delegated), access scopes (administrative domains in IPAM to determine the entities that the user has access to), and access policies (combine a role with an access scope to assign permission to a user or group). Such capabilities give administrators the needed flexibility to confidently administer their large cloud environments.

Highly scalable and customizable

IPAM provides a comprehensive set of Windows PowerShell cmdlets to facilitate operations and to enable integration with various other systems in the network. In addition, IPAM database now supports SQL Server as an optional backend to help enable large-scale solutions.

IPAM Distributed Architecture

With a distributed IPAM architecture, you deploy an IPAM server to every site in an enterprise. This mode of deployment helps reduce network latency in managing infrastructure servers from a centralized IPAM server.

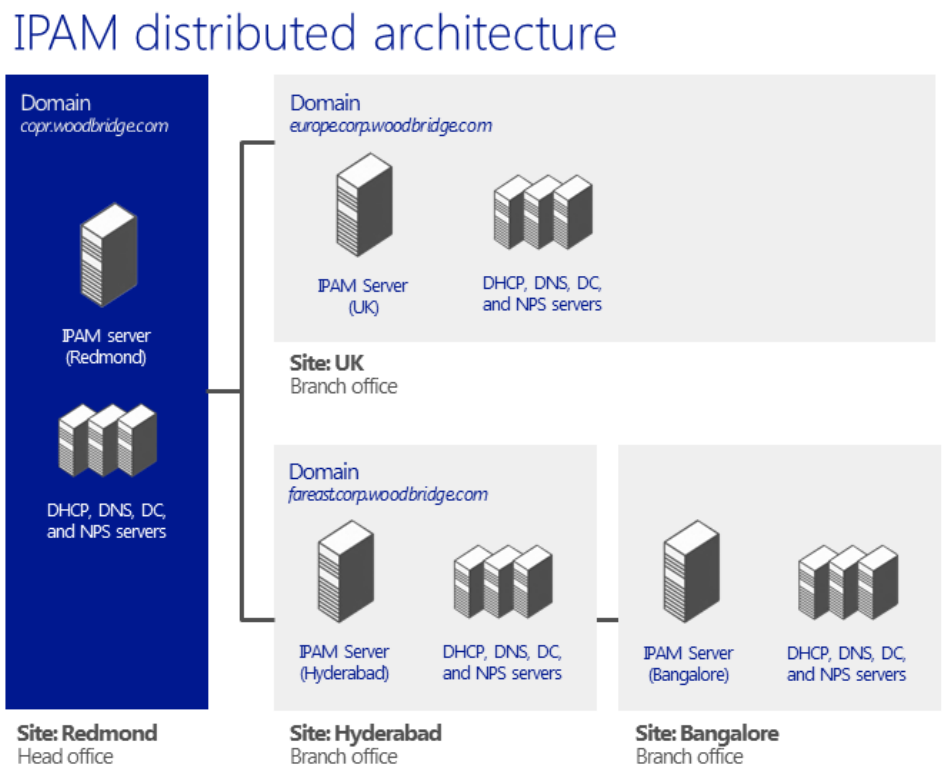

Figure 24: An IPAM-distributed architecture.

IPAM Centralized Architecture

With a centralized deployment of IPAM, you deploy a single IPAM server to an entire datacenter or enterprise. The benefit of this configuration is that administrators have a single console to visualize, monitor, and manage the entire IP address and the associated infrastructure servers. For example a centralized IPAM server, located at the corporate headquarters, handles discovery, monitoring, address space, event collection, and server management duties for the entire enterprise (see Figure 25).

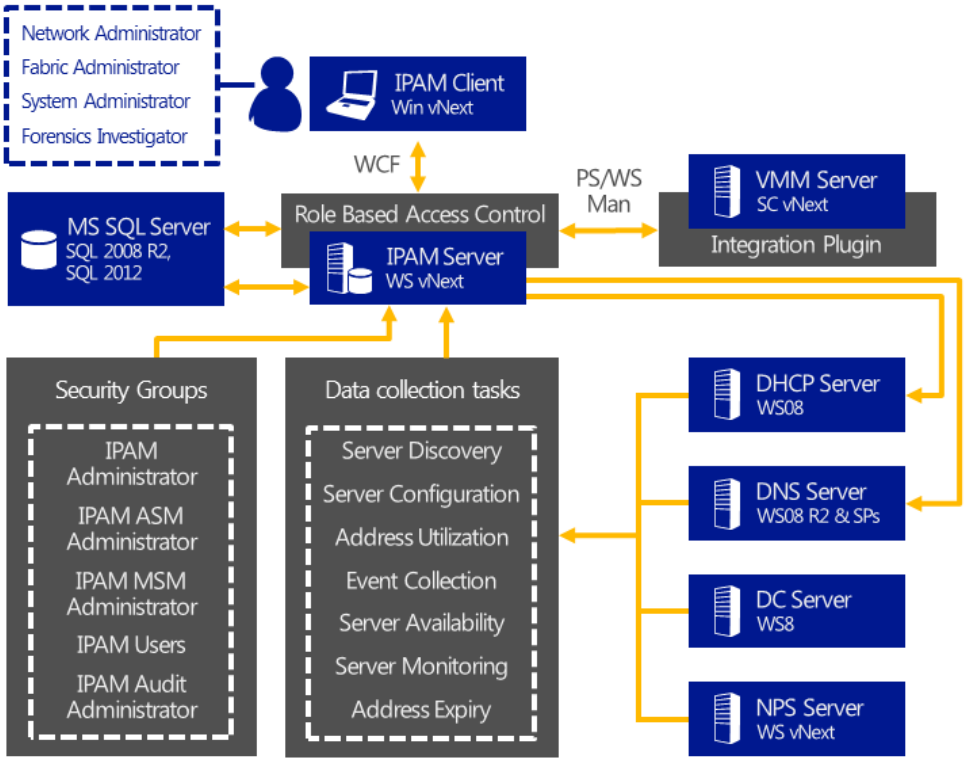

Figure 25: A centralized deployment of IPAM.

IPAM monitoring

IPAM periodically attempts to locate the domain controller, DNS, and DHCP servers on the network that are within the scope of discovery. Network Policy Server (NPS) controls policy and sets the scope for manual or automatic discovery of managed infrastructure services. You must choose whether these servers are managed by IPAM. For a server to be managed by IPAM, server security settings and firewall ports must be configured to enable IPAM server access to perform the required monitoring and configuration functions. You can choose to manually configure these settings or use Group Policy objects (GPOs) to configure them automatically. If you choose the automatic method, settings are applied when a server is marked as managed and removed when it is marked as unmanaged.

The IPAM server communicates with managed servers by using a remote procedure call (RPC) or by utilizing of the following methods:

- IPAM supports Active Directory–based auto-discovery of DNS and DHCP servers on the network. Discovery is based on the domain and server roles selected during configuration of the scope of discovery.
- IPAM discovers the domain controller, DNS servers, and DHCP servers in the network and confirms their availability based on role-specific protocol transactions. In addition to automatic discovery, IPAM also supports the manual addition of a server to the list of servers in the IPAM system.
- IPAM uses SQL Server for storing data if managing at scale and uses SQL Server reporting functionality to build additional reporting.

IPAM data collection tasks

IPAM schedules the following tasks for retrieving data from managed servers to populate the IPAM views for monitoring and management. You can also modify these tasks by using Task Scheduler.

- **Server Discovery**

    - Automatically discovers domain controllers, DHCP servers, and DNS servers in the domains that you select
- **Server Configuration**
    - Collects configuration information from DHCP and DNS servers for display in IP address space and server management functions
- **Address Use**
    - Collects IP address space-use data from DHCP servers for display of current and historical use
- **Event Collection**
    - Collects DHCP and IPAM server operational events
    - Collects events from domain controllers, NPS, and DHCP servers for IP address tracking
- **Server Availability**
    - Collects service status information from DHCP and DNS servers
- **Service Monitoring**
    - Collects DNS zone status events from DNS servers
- **Address Expiry**
    - Tracks IP address expiry state and logs notifications

IPAM Benefits

- Offers inbox feature for integrated management of IP addresses, domain names, and device identities
- Tightly integrates with Microsoft DNS and DHCP servers
- Provides custom IP address space display, reporting, and management
- Audits server configuration changes and tracks IP address use
- Migrates IP address data from spreadsheets or other tools
- Monitors and manages specific scenario-based DHCP and DNS services

Windows PowerShell Support

In Windows Server 2012 R2, every administrative operation is now available through the scriptable Windows PowerShell command shell interface. This support enables IT professionals to build solid automation for the datacenter to take care of regular tasks, freeing up administrators' valuable time.

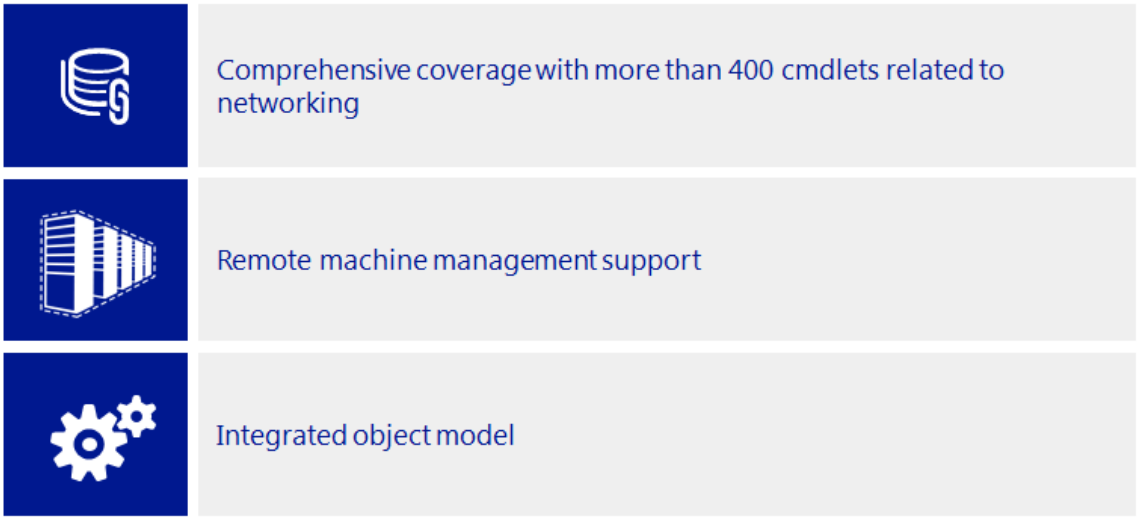

Figure 26: Windows PowerShell Benefits.

Hyper-V Resource Metering

Better insight into as well as improved manageability and control over your network assets are important challenges that IT professionals face on a daily basis. No matter the size of your organization, you need to have the ability to get the best performance on a multi-site environment and provide your organization and hosting providers with a way to track resource usage and build chargeback/show-back solutions.

At a glance: Resource Metering

Hyper-V Resource Metering captures resource usage by virtual machine, grouped by resource pools and virtual machine groups in the following categories:

- CPU
- Memory
- Disk
- Network

Challenges

- The aggregation of resource usage data
- Capacity planning and resource usage trending
- Collecting and compiling information for billing and resource management reporting

Solution

Hyper-V in Windows Server 2012 R2 helps providers build a multi-tenant environment in which virtual machines can be served to multiple clients in a more isolated and secure way (see Figure 27).

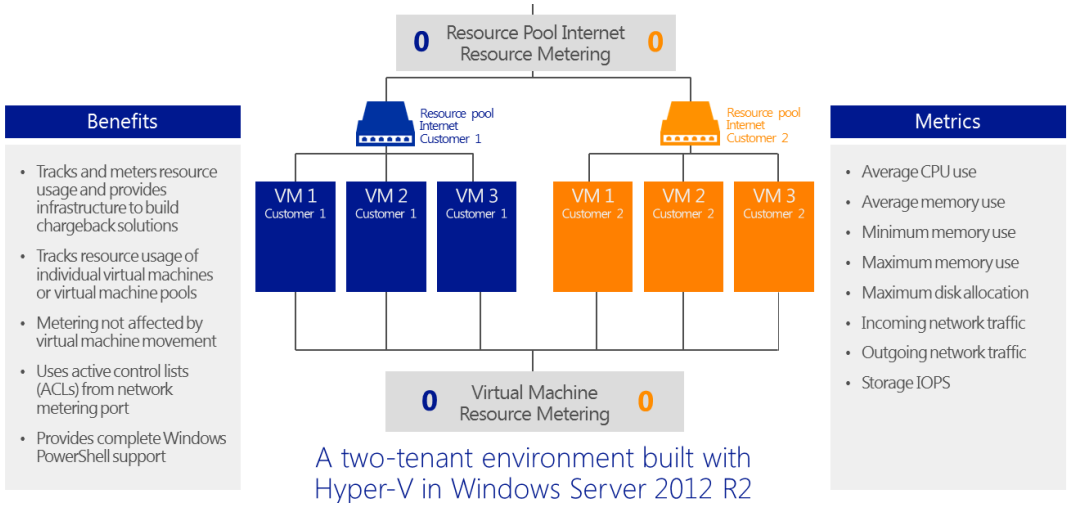

Figure 27: A multi-tenant environment built with Hyper-V.

Because a single client can have many virtual machines, aggregation of resource use data can be a challenging task. However, Windows Server 2012 R2 simplifies this task by using resource pools, a feature available in Hyper-V. Resource pools are logical containers that collect the resources of the virtual machines that belong to one client, permitting single-point querying of the client's overall resource use.

With resource metering, you can measure the following:

- The average CPU, in megahertz, used by a virtual machine over a period of time
- The average physical memory, in MBs, used by a virtual machine over a period of time
- The lowest amount of physical memory, in MBs, assigned to a virtual machine over a period of time
- The highest amount of physical memory, in MBs, assigned to a virtual machine over a period of time
- The highest amount of disk space capacity, in MBs, allocated to a virtual machine over a period of time
- The total incoming network traffic, in MBs, for a virtual network adapter over a period of time
- The total outgoing network traffic, in MBs, for a virtual network adapter over a period of time

Resource Metering Benefits

- Customers can collect resource usage data for virtual machines belonging to one or many clients.
- Resource usage metadata and configuration follows the virtual machine during live or offline migrations
- Network metering port ACLs (PACLs) can differentiate between Internet and intranet traffic

Remote Live Monitoring

Remote Live Monitoring enables network managers to capture traffic from a particular virtual machine. The network managers can then analyze and troubleshoot the virtual machine or its applications without interrupting the workload that's running.

At a glance: Remote Live Monitoring

- Traffic-capturing mechanism
- Simple setup
- Good for forensics and troubleshooting
- WMI and ETW support

Challenges

Network administrators need a way to remotely monitor or capture packets that are sent to or from a virtual machine in their charge.

Solution

Windows Server 2012 introduced monitoring of network traffic on a remote server. With Windows Server 2012 R2, you can easily mirror or capture network traffic on a remote computer view, locally or remotely. This functionality is particularly useful with virtual machines in private cloud environments.

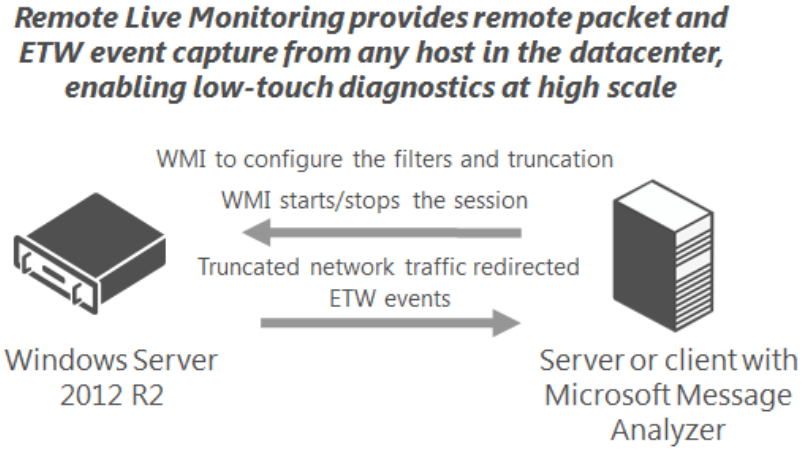

Figure 28: Remote Live Monitoring.

Message Analyzer provides a full graphical user interface as part of Windows Server 2012 R2. You can now make offline captures on remote computers and collect those captures when you reconnect. When setting up a capture, you cannot only filter by ports and IP addresses, but by source virtual machine. The service returns Event Tracing for Windows (ETW) events back to the client running Microsoft Message Analyzer.

At a glance: System Center 2012

- Manages switch extensions
- Provides Inbox NV Gateways
- Offers Load balancer plugins from a centralized location
- Applies policies to hosts and virtual machines in a consistent fashion

Networking and Isolation in the Private Cloud using System Center 2012

Customers and cloud administrators need a way to manage virtualized networks at scale while delivering the levels of isolation and automation required for specific needs. They also need to take advantage of existing network appliances with a set of providers that can connect to load balancers, switch extension managers, and network virtualization gateways. This functionality lays the groundwork for load balancing clouds, logical networks, and host groups the same way you would a physical network.

Challenges

- Difficulties manually managing virtualized network setup and administration
- Time-consuming manual application of policy to hosts and virtual machines

Solution

Datacenters need increased visibility into the network infrastructure (logical and physical). This capability helps to identify service availability issues and responsiveness/performance issues, which are caused by the underlying network. These tools need to be centrally available to the network monitoring team.

System Center 2012 R2 gives IT staffs the tools to drive needed automation and control. With System Center 2012 R2 you gain consistent management experiences that span across Windows Server and Windows Azure environments, including provisioning, automation, self-service, and monitoring.

Remote Live Monitoring Benefits

- Provides integrated GUI experience with Message Analyzer
- Collects offline traffic captures from remote computers
- Provides filters to select packets by IP addresses and virtual machines
- Captures ETW events for remote and local viewing

System Center 2012 R2 Virtual Machine Manager (SCVMM)

SCVMM 2012 R2 is a core component of the System Center 2012 R2 suite. With SCVMM 2012 R2, you can centrally manage compute, storage and networking resources in your datacenter or private cloud. A hoster can implement SCVMM 2012 R2 to manage all of their Hyper-V, VMware, Citrix hosts, and virtual machines.

At a glance: SCVMM 2012 R2

- Policy-based deployment of scalable virtual networks
- Cloud-level management and monitoring for all aspects of the cloud
- Automated virtual machine
- Provisioning and online cloning
- Highly available with Failover Clustering

Challenges

- Management overhead grows exponentially with every tenant and cloud environment added to the infrastructure
- Without automation, manual configurations and deployments of virtual networks is difficult on a large scale, especially for multi-vendor clouds

Solution

With SCVMM 2012 R2, you can configure virtual networks and virtual switches and push those configurations out to any number of hosts. SCVMM 2012 R2 also helps you manage how logical networks overlay the physical network fabric of the datacenter through advanced tools and consoles used for setup and deployment of NVGRE, NAT, and BGP policies.

In addition, SCVMM 2012 R2 includes gateway services, such as the Multi-Tenant VPN gateway. Repeatable virtual updates and configuration changes are easy to deploy to any number of Hyper-V hosts. This configuration data stays with the virtual machine even if it is migrated to another host in the cloud infrastructure.

You can use SCVMM 2012 R2 for more than Hyper-V. In fact, you can use SCVMM 2012 R2 to centrally manage your entire cloud infrastructure of Hyper-V, VMware, or Citrix servers. This functionality includes the centralized management and provisioning of the virtual machines on those hosts. For more on System Center 2012 R2 Virtual Machine Manager, see: http://blogs.technet.com/b/scvmm/.

Virtual Network Isolation

In SCVMM 2012 R2, you can isolate virtual machine networks using either traditional VLAN/PVLANS or, if you are using Windows Server 2012 R2 as your host operating system, you can choose to implement SDN to scale with SCVMM 2012 R2. The latter option addresses the scale limitations associated with a traditional VLANs solution as well as enables tenants to bring their own network or otherwise extend their network into your environment. The diagram at the link below shows each of these options and acts as a reference for the detailed discussion that follows.

Private Virtual LANs (PVLANS) are often used by hosters to work around the scale limitations of VLANS, essentially enabling network administrators to divide a VLAN into a number of separate and isolated sub-networks, which can then be allocated to individual customers (tenants). PVLANs share the allocated IP subnet to the parent VLAN. From a security perspective, although hosts connected to different PVLANs still belong to the same IP subnet, they require a router to communicate with each other and with resources on any other network.

A PVLAN consists of a primary and secondary VLAN pair, with each pair capable of being configured in one of three modes (see Figure 28). In Promiscuous mode, hosts are on the primary VLAN and are able to communicate directly with resources on the primary VLAN and also the secondary VLAN. In a Community mode, the secondary VLAN represents a community. Direct communication is permitted only with hosts in the same community and those that are connected to the Primary PVLAN in promiscuous mode. Isolated PVLANs only permit direct communication with promiscuous resources that exist in the Primary PVLAN.

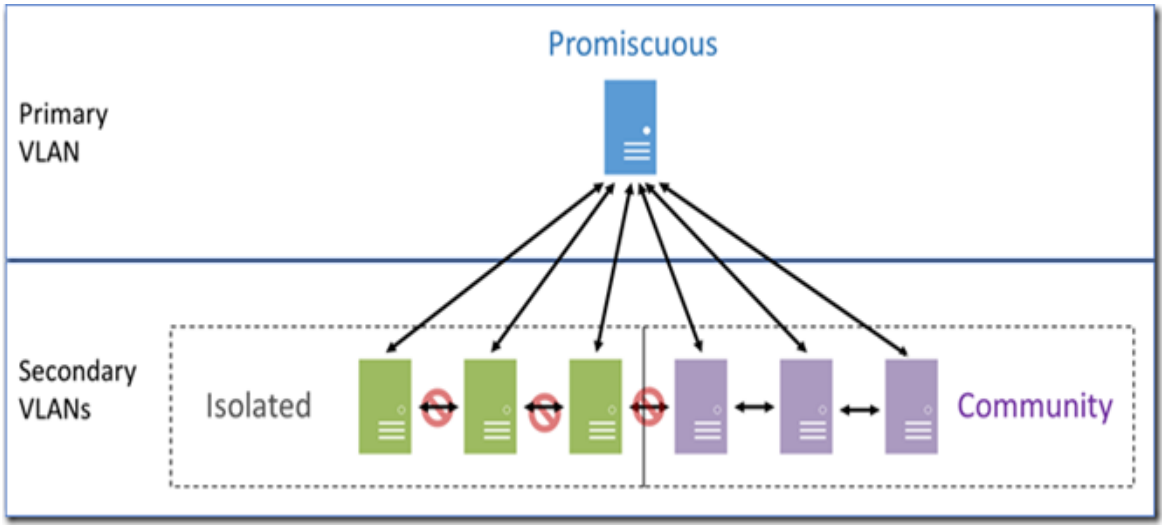

Figure 29: A PVLAN consists of a primary and secondary VLAN pair.

SCVMM 2012 R2 only supports isolated mode (as described above) and has no concept of primary (promiscuous) or community modes. What this means in practice is that a virtual machine connected to a PVLAN is completely isolated from any other resources on the network. The only device it can directly communicate with is the default IP gateway. While this functionality may feel like a severe limitation, there are a number of scenarios which work quite well in this configuration - the most common example being front-end web servers. In this specific scenario, all of the web servers in a web farm are placed on a single network subnet but are otherwise completely isolated from each other. Here PVLANs help to simplify management and improve overall security.

SCVMM 2012 R2 builds on standard PVLAN isolation by giving network administrators a console for building the logical networks and configuring abstraction of those networks over the top of physical networks. With the ability to create one or more private clouds, administrators can now provide for the different networking needs of their customers by using the logical network layers instead of having to assign each

application or virtual machine to a particular NIC on the Hyper-V host. SCVMM 2012 R2 can manage all your Hyper-V, VMware, and Citrix Servers from one console and provide a cloud-level view of all resources, as well as provide end-to-end network monitoring.

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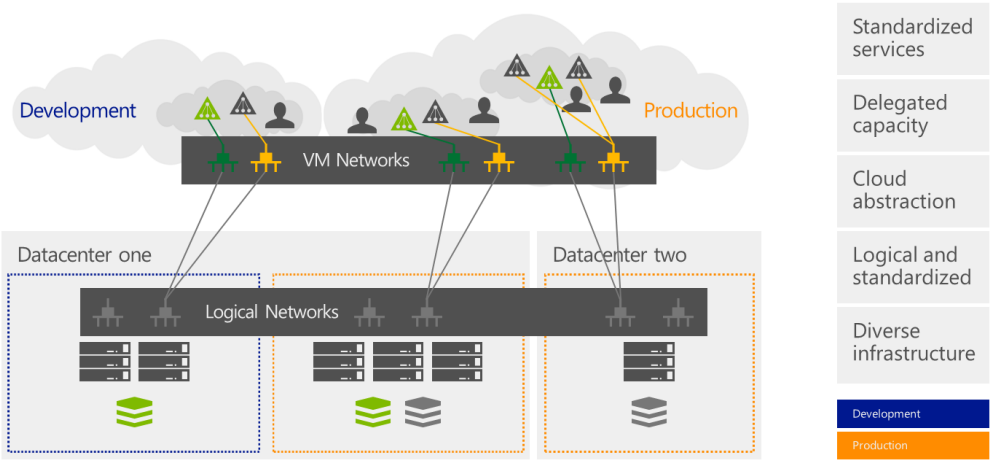


Figure 30: SCVMM 2012 R2 helps give network administrators a console for building logical networks and configuring abstraction

SCVMM 2012 R2 includes providers that can connect to load balancers, switch extension managers, and network virtualization gateways. These providers enable the following functionality:

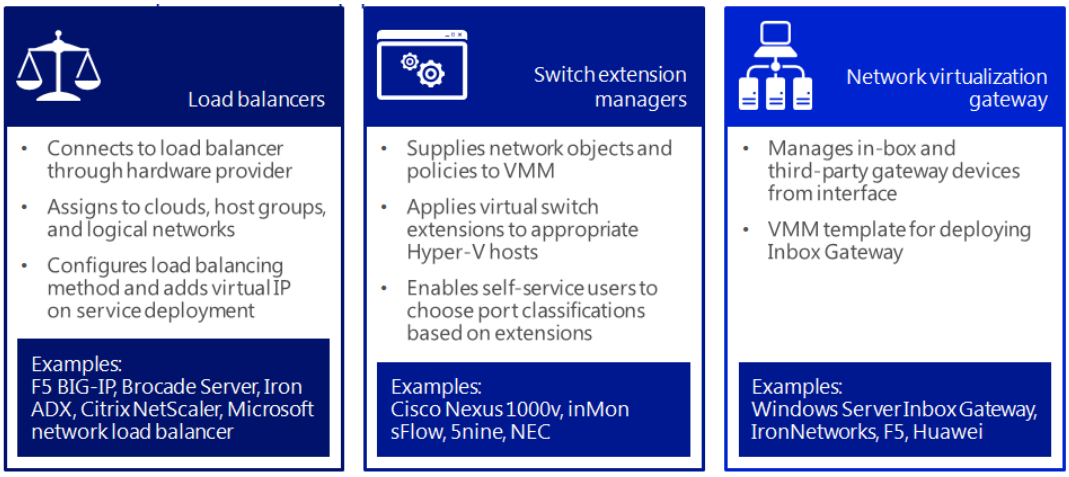


Figure 31: SCVMM 2012 R2 provider-enabled functionality.

Load Balancers

SCVMM 2012 R2 can use a hardware provider to connect to and control a load balancer. The load balancer can then be assigned to clouds, host groups, and logical networks (depending on the requirements of the network topology). SCVMM 2012 R2 can configure the load balancing method (round robin, ratio, dynamic ratio, fastest node and so on) and assign a virtual IP address to the load balancer when the device is deployed. Examples of supported load balancers include F5 BIG-IP, Brocade Server, Iron ADX, Citrix NetScaler, and Microsoft Network Load Balancing.

Network Virtualization Gateway

SCVMM 2012 R2 can manage in-box and third party network virtualization gateways directly from the management interface.

SCVMM 2012 R2 Benefits

- Enables cloud administrators to enforce the proper levels of isolation, even if the virtual machine is or moved to a different host on a different network, or to a different datacenter.
- Increases visibility into the network infrastructure
- Utilizes Virtualization Gateway, switch extensions, and load balancer providers to help network administrators make better use of their existing physical infrastructure appliances

System Center 2012 R2 Operations Manager

System Center 2012 R2 Operations Manager can also carry out network device monitoring. The benefits of this approach are as follows:

- Increases visibility into the network infrastructure
- Helps to identify service availability and responsiveness or performance issues caused by the underlying network
- Shows how network devices are physically connected to servers
- Enables informed conversations about service outages with the network monitoring team

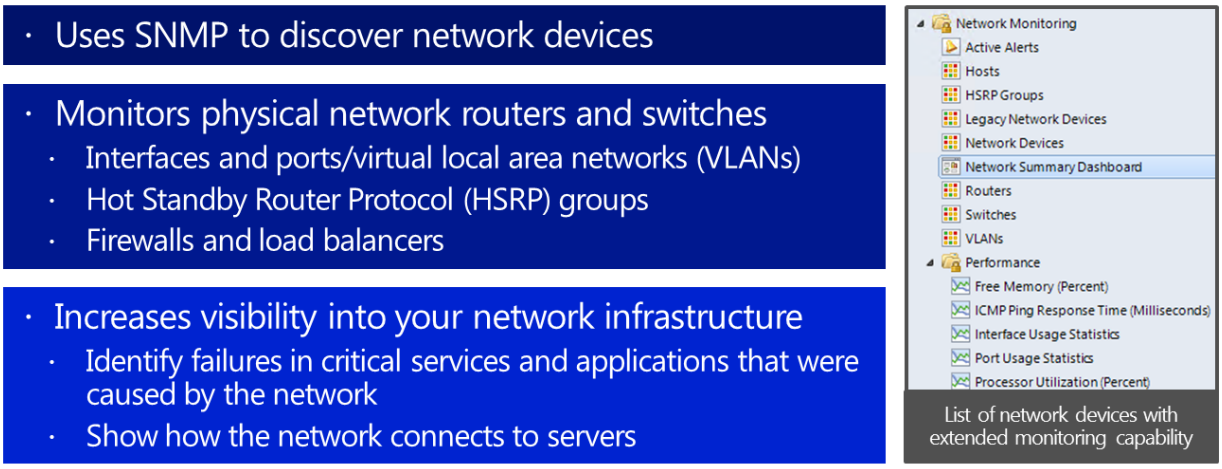


Figure 32: System Center Operations Manager 2012 R2 benefits.

System Center 2012 R2 Operations Manager provides the ability to discover and monitor network routers and switches, including the network interfaces and ports on those devices and their VLAN uses. System Center 2012 R2 Operations Manager can tell you whether network devices are online or offline and can monitor the ports and interfaces for those devices.

Comprehensive end-to-end view of network

System Center 2012 R2 Operations Manager provides a comprehensive end-to-end view of the network through the Network Summary Dashboard and the health view for network devices.

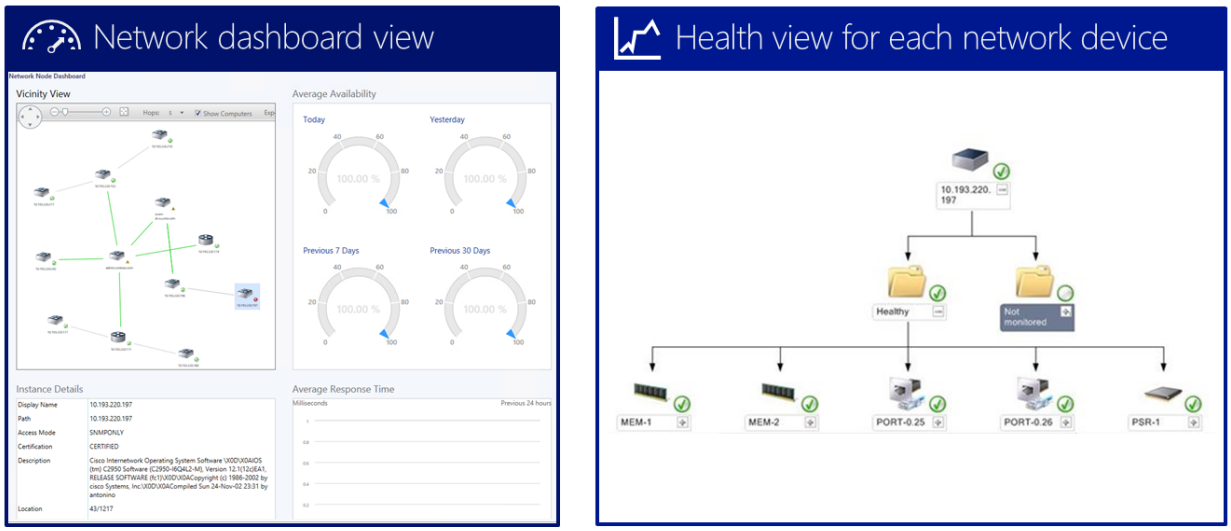


Figure 33: Different network views from System Center 2012 R2 Operations Manager.

The Network Summary Dashboard view provides a view of important data for the nodes and interfaces of the network. This dashboard view can display the following information:

- Nodes with Slowest Response (ICMP ping)
- Nodes with Highest CPU Usage
- Interfaces with Highest Utilization
- Interfaces with Most Send Errors
- Interfaces with Most Receive Errors
- Nodes with the Most Alerts
- Interfaces with the Most Alerts

You can use the Network Vicinity Dashboard to view a diagram of a node and all nodes and agent computers that are connected to that node. The Network Vicinity Dashboard view displays one hop or level of connection. However, you can configure the view to display up to five levels of connection. The diagram displays the health of the nodes and the connections between nodes.

System Center 2012 R2 Operations Manager Benefits

- Eliminates gaps in network device monitoring.
- Provides end-to-end distributed view of the entire network infrastructure to troubleshoot and resolve the issue effectively.
- Helps to identify service availability, responsiveness or performance issues caused by the underlying network
- Shows how network devices are physically connected to servers
- Enables informed conversations about service outages with the Network Monitoring Tea

Networking in the Hybrid Cloud

Microsoft has been working with partners in the industry to bring a great variety of choices for customers to connect their private clouds to off-premise hosters. Delivering on the promise of a modern datacenter, modern applications, and people-centric IT, Windows Server 2012 R2 provides a best-in-class server experience that cost-effectively cloud-optimizes your business.

Multi-tenant gateway services for site-to-site (S2S) VPN connections have been improved in Windows Server 2012 R2 so that hosters can share VPN services across all clients, instead of having to deploy a separate VPN and NAT model for each.

In addition, off-premise hosting of mission-critical resources has been simplified to integrate with your internal datacenters.

Cross-premises connectivity

Challenges

- Simplifying cross-premise connectivity between enterprises and hosting service providers
- Improving S2S security for multi-tenant cloud environments
- Customers must be able to connect private subnets to a hosted cloud environment while maintaining the NVGRE logical network routing and packet filtering that exists on premise
- Gateway services must be able to support multiple clients' S2S VPN connections at the same time
- Network security must be able to be enforced using the industry standard IKEv2-IPsec protocol
- Windows Azure customers need to be able to extend their in-house virtual networks to isolated sections in Windows Azure that they can treat as an extension of their datacenters

Solution

Windows Server 2012 R2 provides a highly cloud-optimized operating system. VPN site-to-site functionality in remote access provides cross-premises connectivity between enterprises and hosting service providers. Cross-premises connectivity enables enterprises to do the following:

- connect to private subnets in a hosted cloud network
- make connections between geographically-separate enterprise locations.
- use their existing networking equipment to connect to hosting providers using the industry standard IKEv2-IPsec protocol.

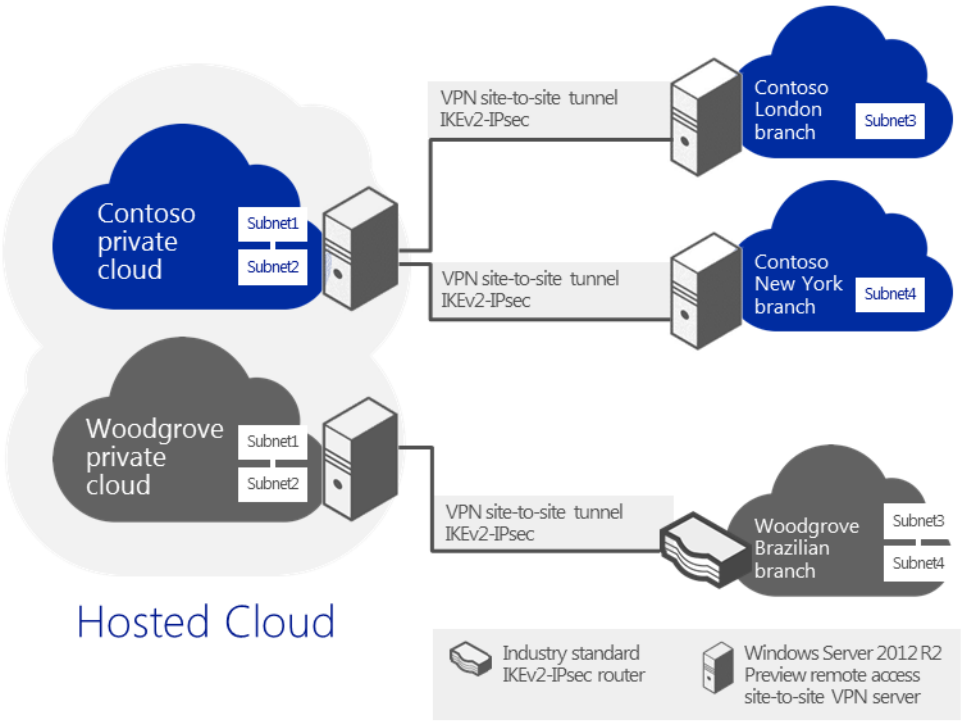


Figure 34: Windows Server 2012 R2 provides a highly cloud-optimized operating system.

Hybrid networking in Windows Server 2012

In Windows Server 2012, the S2S VPN was part of RAS and each tenant required a separate VPN host in order to enforce isolation. Other components included the following:

- S2S VPN as part of Remote Access Server
- Required Windows Network Virtualization
- Required one virtual machine per tenant for the gateway

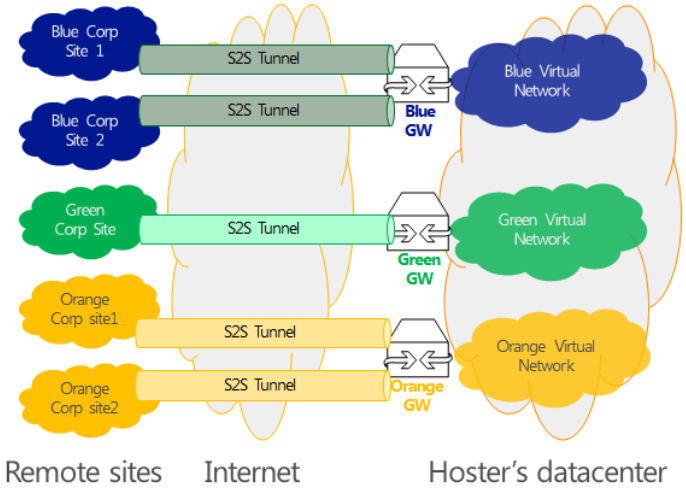


Figure 35: Hybrid networking in Windows Server 2012 R2.

Hybrid networking in Windows Server 2012 R2

In Windows Server 2012 R2, a separate multi-tenant S2S gateway is now available. The new gateway supports high availability though guest clustering. In addition, the new gateway uses BGP for dynamic route updates and provides multi-tenant services so that a single gateway can now support multiple clients. Other features include the following:

- Provides multi-tenant S2S gateway
- Includes guest clustering for high availability
- Uses BGP for dynamic routes update
- Provides multi-tenant-aware NAT for Internet access

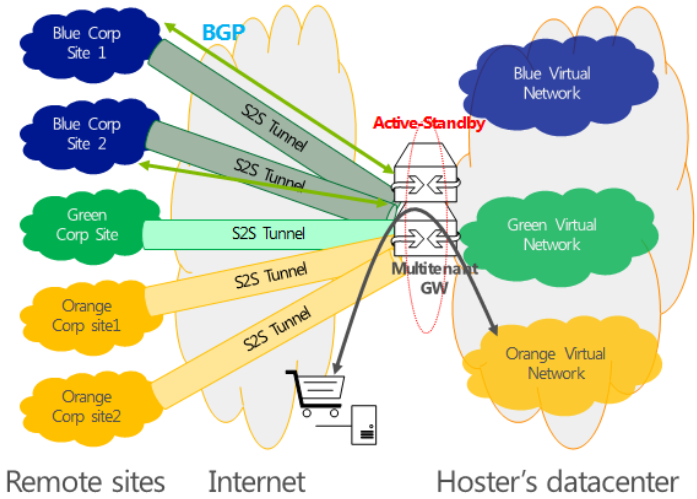


Figure 36: Hybrid networking in Windows Server 2012 R2.

Connecting Private Clouds with Windows Azure and Hoster

Virtual network in Windows Azure enables you to create private, isolated sections in Windows Azure that you can treat as an extension of your datacenter. For example, you can assign private IP addresses to virtual machines inside a virtual network, specify DNS settings, and connect this virtual environment to your on-premises infrastructure using a VPN device over a site-to-site or S2S connection.

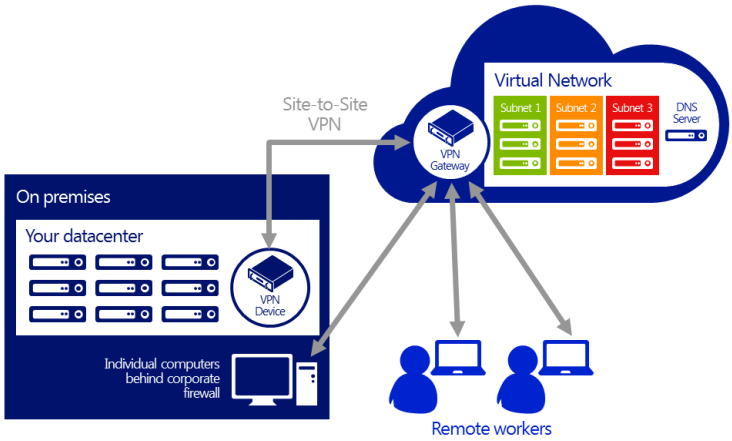
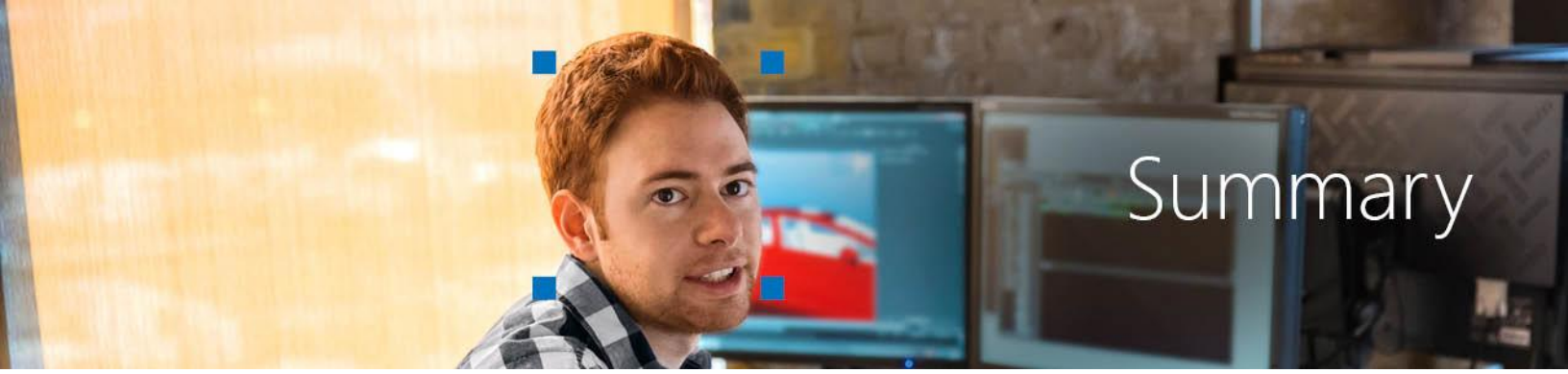


Figure 37: Virtual Network in Windows Azure set up.

Windows Server 2012 R2 uses the existing S2S VPN connectivity so that you no longer have to invest in a hardware VPN device to connect your on-premises network to Windows Azure. Instead, you can just use the Routing and Remote Access Service (RRAS).

A new feature in Windows Server 2012 R2 is the Point-to-Site (P2S) VPN, which enables you to set up VPN connections between individual computers and an Windows Azure virtual network without the need for a VPN device. This feature greatly simplifies establishing secure connections between Windows Azure and client machines (from your office environment or from remote locations) and enables you to connect to Windows Azure virtual networks in the following ways:

- Users can securely connect to your Windows Azure environment from any location. For instance, developers can connect their laptops to a test and development environment and continue to code from almost anywhere.
- Small businesses (or departments within an enterprise) who don't have existing VPN devices and/or network expertise to manage VPN devices can rely on the P2S VPN feature to connect securely to your Windows Azure deployments.
- Users can quickly set up secure connections without the involvement of a network administrator, even if their computers are behind a corporate proxy or firewall.
- Independent Software Vendors (ISVs) wanting to provide secure access to their cloud applications can use the P2S VPN feature to offer a seamless application experience.



Summary

The new and improved features in Windows Server 2012 R2 make this operating system the best platform for cloud-based deployments and for managing physical and virtual network devices in conjunction with System Center 2012 R2 .

ADVANCING SOFTWARE DEFINED NETWORKING	DELIVERING CONTINUOUSLY AVAILABLE APPLICATIONS	IMPROVING NETWORK PERFORMANCE	SIMPLIFYING DATACENTER NETWORK MANAGEMENT	NETWORKING IN THE HYBRID CLOUD
• Hyper-V Network Virtualization • Hyper-V Extensible Switch	• SMB Multichannel • DHCP Failover • QoS	• SMB Direct (RDMA) • Virtual RSS • HNV Task and Traffic Offload • NIC Teaming • SR-IOV	• IP Address Management • Microsoft Windows PowerShell • Resource Metering • Network Management with Virtual Machine Manager • Network Monitoring with Operations Manager	• Cross-Premise Connectivity • Extending to Azure • Extending to Service Providers

Please take some time and evaluate Windows Server 2012 R2 and System Center 2012 R2 to experience, first-hand, some of incredible capabilities of the latest Microsoft cloud-ready operating system and management tools. Here are some resources to help get you started:

Windows Server 2012 R2 Download:
http://www.microsoft.com/en-us/server-cloud/windows-server/windows-server-2012-r2.aspx

Windows Server 2012 R2 Features Whitepaper:
http://download.microsoft.com/download/0/2/1/021BE527-A882-41E6-A83B-8072BF58721E/Windows_Server_2012_R2_Overview_White_Paper.pdf

Windows Server 2012 R2 Hyper-V:
http://technet.microsoft.com/evalcenter/dn205299

Windows Azure based Virtual Machine Implementation:
http://www.windowsazure.com/en-us/home/features/virtual-machines/

System Center 2012 R2 Download:
http://www.microsoft.com/en-us/server-cloud/system-center/system-center-2012-r2.aspx

System Center 2012 R2 Features Whitepaper:
http://download.microsoft.com/download/7/7/2/7721670F-DEF0-40D3-9771-43146DED5132/System_Center_2012%20R2_Overview_White_Paper.pdf