Windows Server 2016 Converged NIC and Guest RDMA Deployment: A Step-by-Step Guide

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# Introduction to the Deployment Guide

The Instructions below provide the detailed steps to deploy and diagnose Windows Server 2016 and Windows Server 1709 Converged NIC and Guest RDMA deployments. This paper covers both RoCEv2 and iWarp deployment. To the degree that we are aware of differences between RDMA technologies and vendor-specific requirements, we have included those differences in this paper.

***Microsoft Recommendation:*** While the Microsoft RDMA interface is RDMA-technology agnostic, in our experience with customers and partners we find that RoCE/RoCEv2 installations are difficult to configure correctly and are problematic at any scale above a single rack.  If you intend to deploy RoCE/RoCEv2, you should a) have a small scale (single rack) installation, and b) have an expert network administrator who is intimately familiar with Data Center Bridging (DCB), Enhanced Transmission Service (ETS), and Priority Flow Control (PFC).  If you are deploying in any other context iWarp is the technology most likely to succeed.  iWarp does not require any configuration of DCB on network hosts or network switches and can operate over the same distances as any other TCP connection.RoCE, even when enhanced with Explicit Congestion Notification (ECN) detection, requires network configuration to configure DCB/ETS/PFC and/or ECN especially if the scale of deployment exceeds a single rack.  Tuning of these settings, i.e., the settings required to make DCB and/or ECN work, is an art not mastered by every network engineer.

RoCE vendors have been very actively working to reduce the complexity associated with RoCE deployments. See the list of resources (Appendix 2) for more information about vendor specific solutions. Check with your NIC vendor for their recommended tools and deployment guidance.

## **How to read this guide**

The instructions in this guide apply to two configurations (see Figure 1 and Figure 2).

* The Instructions in this document marked in GREEN are for BASIC single adapter scenarios only. This is the case where only the minimal set of operations and resources are desired.
* The instructions in this document marked in BLUE are for the recommended Dual-port configuration Datacenter deployment with multiple RDMA Host vNICs for maximum performance and availability.
* The instructions in BLACK apply to both configurations.

When the output from PowerShell cmdlets is shown, the important parts of the output are highlighted in yellow.

## **Scope of this Guide**

This guide covers Windows Server 2016 and Windows Server 1709. Where differences exist, they are called out. Guest RDMA is only supported in Windows Server 1709.

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## **RDMA modes of operation**

The Network Direct Kernel-mode Provider Interface (NDKPI), which specifies how an RDMA-capable NIC should interface with the Windows Operating System, defines three modes of operation:

* NDKPI Mode 1: Native host to Native host communication
* NDKPI Mode 2: RDMA exposed on the Host virtual interface of a Hyper-V Switch (also known as “Converged NIC”)
* NDKPI Mode 3: RDMA exposed on the Guest virtual interface through an SR-IOV virtual function (also known as “Guest RDMA”)

This document covers all three scenarios. Any RDMA interface in a Windows host, no matter which mode of operation it is in, can communicate to any other RDMA interface in any other Windows host as long as both systems support the same RDMA protocol (e.g., iWarp or RoCEv2). The mode applies only to the local RDMA interface. Specifically,

* A Native host RDMA interface (e.g., a File Server) can communicate with another Native host, a Converged NIC instance, or a Guest RDMA instance.
* A Converged NIC instance can communicate with a Native host instance, another Converged NIC instance, or a Guest RDMA instance.
* A Guest RDMA instance can communicate with a Native host instance, a Converged NIC instance, or another Guest RDMA instance.

## **Terminology**

|  |  |
| --- | --- |
| iWarp | RDMA over TCP |
| pNIC | Physical NIC, the physical hardware that exchanges packets with the TOR |
| RoCE | RDMA over Converged Ethernet |
| RoCEv2 | 2nd generation RoCE using UDP/IP for routability (a.k.a. Routable RoCE) |
| TOR | Top of Rack switch |
| vmNIC | Virtual Machine NIC – Virtual NIC from vSwitch exposed in a guest partition |
| vNIC | Host vNIC – Virtual NIC from vSwitch exposed in the host partition |
| vSwitch | Hyper-V virtual switch |

## **Intended configurations**

For this paper we assume one of the two following configurations are the goal. We further assume the administrator has two hosts with the same physical configuration available, i.e., either two of the single NIC hosts or two of the two-NIC hosts. The paper starts with only the operating system installed and only fully configures one host.

|  |  |
| --- | --- |
| Figure 1 - RDMA with single NIC | Figure 2 - RDMA with SET Teamed NICs |

# Step 1: Test Basic Connectivity

Let’s start with just the Operating System (Windows Server 1709) installed. We’ll add Hyper-V and the other needed components later in this process.

## **Step 1a – Single pNIC configuration**

Single NIC configuration

Rename the pNIC to “NIC1” in each host. This optional step makes it possible to reuse the PowerShell cmdlets below as shown.

PS> Rename-NetAdapter Ethernet NIC1

Check that the name change took effect.

PS> Get-NetAdapter

Name InterfaceDescription ifIndex Status MacAddress LinkSpeed

---- -------------------- ------- ------ ---------- ---------

NIC1 Chelsio Network Adapter 3 Up 00-07-43-2D-D6-D8 40 Gbps

**Host A:** Assign IP address 192.168.1.3 to the pNIC

PS> New-NetIPAddress -InterfaceAlias NIC1 -IPAddress 192.168.1.3 -PrefixLength 24

Confirm the addresses have been assigned:

PS> Get-NetIPAddress -InterfaceAlias NIC1 | ft IPAddress

The return should show both the default IPv6 address and the assigned IPv4 address.

IPAddress

---------

fe80::dcaa:bda9:a33a:c570%9

192.168.1.3

**Host B:** Assign IP address 192.168.1.5 to the pNIC

PS> New-NetIPAddress -InterfaceAlias NIC1 -IPAddress 192.168.1.5 -PrefixLength 24

Confirm the addresses have been assigned:

PS> Get-NetIPAddress -InterfaceAlias NIC1 | ft ipaddress

The return should show both the default IPv6 address and the assigned IPv4 address.

IPAddress

---------

fe80::d0f1:81d2:22fd:68a8%11

192.168.1.5

At the end of this step the configuration of your hosts should resemble:

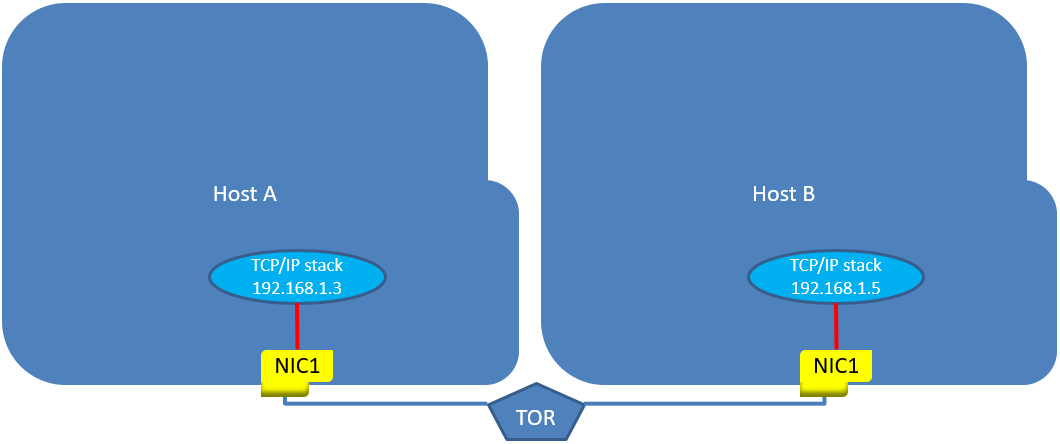


Figure 3 - Single port configuration

## **Step 1a – Dual pNIC configuration**

Two-NIC configuration

Rename the two pNICs in each host to “NIC1” and “NIC2” (this optional step makes it possible to reuse the PowerShell cmdlets below as is).

PS> Rename-NetAdapter Ethernet NIC1

PS> Rename-NetAdapter “Ethernet 2” NIC2

Check that the name changes happened:

Name InterfaceDescription ifIndex Status MacAddress LinkSpeed

---- -------------------- ------- ------ ---------- ---------

NIC2 Chelsio Network Adapter #2 3 Up 00-07-43-2D-D6-D8 40 Gbps

NIC1 Chelsio Network Adapter 4 Up 00-07-43-2D-D6-D0 40 Gbps

**Host A**: Assign IP address 192.168.1.3 to NIC1 and assign IP address 192.168.2.3 to NIC2 on Host A

PS> New-NetIPAddress -InterfaceAlias NIC1 -IPAddress 192.168.1.3 -PrefixLength 24

PS> New-NetIPAddress -InterfaceAlias NIC2 -IPAddress 192.168.2.3 -PrefixLength 24

Confirm the addresses have been assigned:

PS> Get-NetIPAddress -InterfaceAlias NIC1,NIC2 | ft ipaddress

The output should show both the default IPv6 addresses and the assigned IPv4 addresses.

IPAddress

---------

fe80::25d3:1e0d:e9de:20d%12

fe80::b55e:e8dc:dea0:c7dd%7

192.168.1.3

192.168.2.3

**Host B**: Assign IP address 192.168.1.5 to NIC1 and assign IP address 192.168.2.5 to NIC2

PS> New-NetIPAddress -InterfaceAlias NIC1 -IPAddress 192.168.1.5 -PrefixLength 24

PS> New-NetIPAddress -InterfaceAlias NIC2 -IPAddress 192.168.2.5 -PrefixLength 24

Confirm the addresses have been assigned:

PS> Get-NetIPAddress -InterfaceAlias NIC1,NIC2 | ft ipaddress

The output should again show both the default IPv6 address and the assigned IPv4 address.

At the end of this step the configuration of your hosts should look like:

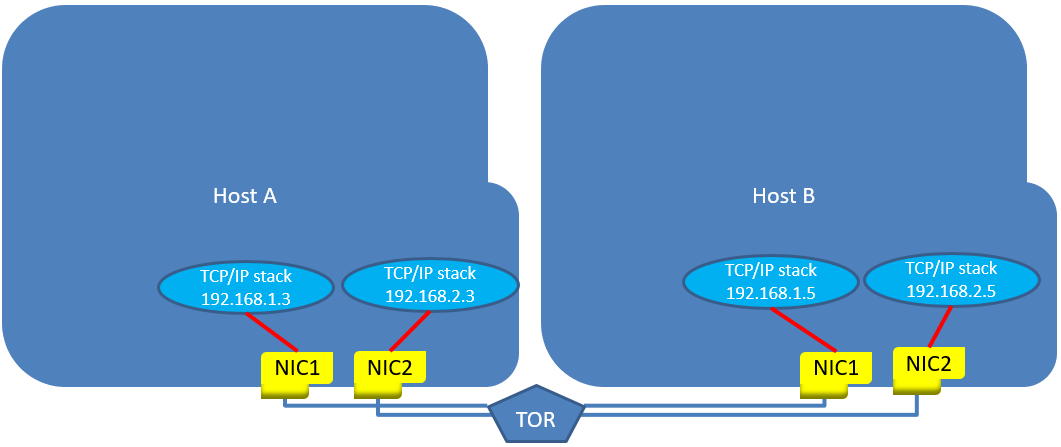


Figure 4 - Dual-port configuration

## **Step 1b – Check to see that the pNIC(s) have connectivity to the TOR**

On each host execute

PS> Get-NetAdapter | ft -Autosize

The response will have the following columns:

Name InterfaceDescription ifIndex Status MacAddress LinkSpeed

---- -------------------- ------- ------ ---------- ---------

NIC1 Chelsio Network Adapter 3 Up 00-07-43-2D-D6-D8 40 Gbps

If the Status is not “Up” or the LinkSpeed is “0 bps” you don’t have connectivity to the TOR from that pNIC. Check the cabling and try again until all interfaces show “Up” with a LinkSpeed that you expect (e.g., “10 Gpbs”).

## **Step 1c – Single pNIC: Check host-to-host connectivity**

**Host A**: Execute

PS> Test-NetConnection 192.168.1.5

The response should look like

ComputerName : 192.168.1.5

RemoteAddress : 192.168.1.5

InterfaceAlias : NIC1

SourceAddress : 192.168.1.3

PingSucceeded : True

PingReplyDetails (RTT) : 0 ms

If the PingSucceeded line is not “True” check your firewall settings to ensure the interface is allowed to communicate to the outside world. Once you have a successful test you are ready to move to the next step.

## **Step 1c – Dual pNIC: Check host-to-host connectivity**

**Host A**: Execute

PS> Test-NetConnection 192.168.1.5

The response should look like

ComputerName : 192.168.1.5

RemoteAddress : 192.168.1.5

InterfaceAlias : NIC1

SourceAddress : 192.168.1.3

PingSucceeded : True

PingReplyDetails (RTT) : 0 ms

If the PingSucceeded line is not “True” check your firewall settings on both Host A and Host B to ensure both the source and destination interfaces are allowed to communicate to the outside world.

Repeat the test with the other address of Host B, i.e.,

PS> Test-NetConnection 192.168.2.5

**Host B**: Repeat the tests to ensure both Host A interfaces are available, i.e.,

PS> Test-NetConnection 192.168.1.3

PS> Test-NetConnection 192.168.2.3

Once you have all four successful tests (two from Host A, two from Host B) you are ready to move to the next step.

# Step 2: Configure VLANs

*Note 1: This step is optional for iWarp. This step should be optional for RoCEv1 and RoCEv2, too, but most network switches don’t handle traffic with marked priorities (DCB Traffic Classes) unless they are also VLAN tagged, so we strongly recommend configuration of VLANs for any RoCE traffic. (More information below in Step 3.)*

*Note 2: At this point in the process the NICs are in ACCESS mode. However, when a switch is created later, the VLAN properties are applied at the vSwitch port level. Given a vSwitch will host multiple VLANs it is necessary for the Physical Switch (ToR) to have its port configured in Trunk mode. Consult the switch vendor documentation for instructions.*

## **Step 2a – Single pNIC: Apply VLAN 101 to both Hosts pNICs**

In both hosts execute:

PS> Set-NetAdapterAdvancedProperty NIC1 -RegistryKeyword VlanID -RegistryValue "101"

Because some adapters only pick up new registry keywords after being restarted, restart the pNIC on each host:

PS> Restart-NetAdapter NIC1

To see that the value has been set, execute:

PS> Get-NetAdapterAdvancedProperty -Name NIC1 | Where-Object {$\_.RegistryKeyword -eq

"VlanID"} | ft -AutoSize

The result should look like one of the lines below:

Name DisplayName DisplayValue RegistryKeyword RegistryValue

---- ----------- ------------ --------------- -------------

NIC1 VLAN ID 101 VlanID {101}

*Note: Different hardware vendors may show different strings in the “Display Name” column.*

## **Step 2a – Dual pNIC: Apply VLAN 101 and VLAN 102 to the Host pNICs**

In both hosts execute:

PS> Set-NetAdapterAdvancedProperty NIC1 -RegistryKeyword VlanID -RegistryValue "101"

PS> Set-NetAdapterAdvancedProperty NIC2 -RegistryKeyword VlanID -RegistryValue "102"

Because some adapters only pick up new registry keywords after being restarted, restart the pNICs on each host:

PS> Restart-NetAdapter NIC1,NIC2

Check to see that the VLAN values have been set

PS> Get-NetAdapterAdvancedProperty -Name NIC1,NIC2 | Where-Object

{$\_.RegistryKeyword -eq "VlanID"} | ft -AutoSize

The result should look like one of the lines below:

Name DisplayName DisplayValue RegistryKeyword RegistryValue

---- ----------- ------------ --------------- -------------

NIC1 VLAN ID 101 VlanID {101}

NIC2 VLAN ID 102 VlanID {102}

*Note: Different hardware vendors may show different strings in the “Display Name” column.*

## **Step 2b – Check that connectivity to the switch and the other host is still present**

Repeat Step 1c (above). If the interfaces do not show “Up” or the LinkSpeed shows “0 Gbps” the interfaces are not ready for use. Wait a short time and check again. It may take several seconds after a restart before the pNIC is visible on the network.

**Single pNIC:**

**Host A**: Execute

PS> Test-NetConnection 192.168.1.5

The response should look like

ComputerName : 192.168.42.100

RemoteAddress : 192.168.42.100

InterfaceAlias : vEthernet (GuestRdma)

SourceAddress : 192.168.42.101

PingSucceeded : True

PingReplyDetails (RTT) : 0 ms

If the PingSucceeded line is not “True”, either

1. the TOR is not set correctly to pass VLAN-tagged traffic. Consult your TOR documentation to ensure the ports on the TOR are set to trunk mode or at least are explicitly set to pass VLAN 102 traffic; or
2. the firewall on one or both hosts have not been set to pass the ping traffic. Check your firewall rules to make sure the firewall is set to pass pings through both directions. (To disable all firewall policies in Windows – not recommended for production environments – use Set-NetFirewallProfiles -All -Enabled FALSE.)

**Dual pNIC**:

**Host A**: Execute

PS> Test-NetConnection 192.168.1.5

The response should look like

ComputerName : 192.168.1.5

RemoteAddress : 192.168.1.5

InterfaceAlias : vEthernet (GuestRdma)

SourceAddress : 192.168.1.3

PingSucceeded : True

PingReplyDetails (RTT) : 0 ms

Repeat the test with the other VLAN, i.e.,

PS> Test-NetConnection 192.168.2.5

If the PingSucceeded line is not “True” in either of the above tests, most likely either

1. the TOR is not set correctly to pass VLAN-tagged traffic. Consult your TOR documentation to ensure the ports on the TOR are set to trunk mode or at least are explicitly set to pass VLAN 102 traffic; or
2. the firewall on one or both hosts have not been set to pass the ping traffic. Check your firewall rules to make sure the firewall is set to pass pings through both directions. (To disable all firewall policies in Windows – **not recommended** for production environments – use Set-NetFirewallProfiles -All -Enabled FALSE.)

# Step 3: Configure DCB

*Note 1: This step is optional for iWarp. However, iWarp may benefit from DCB at large fabric scale, so configure DCB at your discretion.*

*Note 2: Some vendors claim that RoCEv2 with ECN has no requirement for DCB. While RoCEv2 with ECN may work very well in a single-rack environment without DCB, it is Microsoft’s belief that RoCEv2 with ECN will still require DCB at any scale larger than a single rack due to the longer round trip delays and the impact on the required size of buffers throughout the network. We strongly encourage you to configure DCB for any RoCEv2-based RDMA deployment. (DCB is always required for any RoCEv1 deployment. RoCEv1 can’t extend beyond a single Layer 2 broadcast domain, typically a single rack.)*

These steps MUST be done identically on each of the hosts in your set-up.

## **Step 3a: Install DCB**

Install the Data Center Bridging feature in Windows Server.

PS> Install-WindowsFeature Data-Center-Bridging

The response should be:

Success Restart Needed Exit Code Feature Result

------- -------------- --------- --------------

True No Success {Data Center Bridging}

If the Success value is not “True” something has gone remarkably wrong. Try again; contact your support organization if it continues to fail.

## **Step 3B: Set policy for Cluster Heartbeats**

While long a beneficial practice, we are now officially recommending creating a cluster heartbeat bandwidth reservation. This is particularly helpful in 10 Gbps Converged scenarios or where the bandwidth available can be easily oversubscribed. Setup a policy to tag Cluster Heartbeats (port 3343) with a priority tag. In this example, we use priority tag “5”.

The command below leverages a template called Cluster (specified by the -Cluster parameter).

*Note: while this guide uses the tag value 5, any tag value between can be used as long as it is used everywhere through the network in both the hosts and the switches/routers. This should be the highest priority traffic in your environment. If priorities tags are leveraged by the network fabric, please make sure this is properly assigned.*

PS> New-NetQosPolicy "Cluster" -Cluster -PriorityValue8021Action 5

Next you need to enable PFC for the SMB-Direct traffic:

PS> Enable-NetQosFlowControl -priority 5

If the PFC enablement succeeds there is no response.

Finally, you need to reserve some bandwidth for the Cluster Heartbeat traffic. This example uses 1%, as this is the smallest amount that can be reserved. Cluster heartbeats use only a very small portion of traffic (43 Bytes) and so for a 10Gbps Adapter, this is more than enough.

PS> New-NetQosTrafficClass "Cluster" -priority 5 -bandwidthpercentage 1 -algorithm ETS

The response to the traffic class creation should look like:

Name Algorithm Bandwidth(%) Priority PolicySet IfIndex IfAlias

---- --------- ------------ -------- --------- ------- -------

Cluster ETS 1 5 Global

## **Step 3C: Set policy for SMB-Direct**

Set up a policy to tag SMB-Direct packets with a priority tag. In this example we use priority tag “3”. Keep in mind that DCB’s QoS policies apply globally, so SMB packets sent using RDMA (“NetDirect” is synonymous with RDMA) will always get tagged with the value “3” no matter what interface they are sent on. *Note: while this guide uses the tag value 3, any tag value between 1 and 7 inclusive can be used as long as it is used everywhere through the network in both the hosts and the switches/routers.*

PS> New-NetQosPolicy "SMB" -NetDirectPortMatchCondition 445

-PriorityValue8021Action 3

Note: While an SMB template exists, it cannot be used to specify *NetDirect* (RDMA) traffic. For RDMA traffic, please use the NetDirectPortMatchCondition parameter

The response should look like:

Name : SMB

Owner : Group Policy (Machine)

NetworkProfile : All

Precedence : 127

JobObject :

NetDirectPort : 445

PriorityValue : 3

Next you need to enable PFC for the SMB-Direct traffic:

PS> Enable-NetQosFlowControl -priority 3

If the PFC enablement succeeds there is no response.

Finally, you need to reserve some bandwidth for the SMB-Direct traffic. This example uses 50%, but you may want to reserve less or more depending on what you expect the ratio of non-Storage traffic to Storage traffic will be in your facility.

PS> New-NetQosTrafficClass "SMB" -priority 3 -bandwidthpercentage 50 -algorithm ETS

The response to the traffic class creation should look like:

Name Algorithm Bandwidth(%) Priority PolicySet IfIndex IfAlias

---- --------- ------------ -------- --------- ------- -------

SMB ETS 50 3 Global

Finally, set these policies on the interface you want to use

If you are using a Single Port configuration:

PS> Enable-NetAdapterQos -InterfaceAlias NIC1

If you are using a Dual Port configuration:

PS> Enable-NetAdapterQos -InterfaceAlias NIC1,NIC2

## **Step 3D: Block DCBX settings from the switch**

By default Windows Network Adapters (NICs) are allowed to accept DCB settings from the adjacent network switch through the use of the DCBX protocol. However, since the Windows operating system never looks at what settings the switch sent to the NIC, and in the steps in this section Windows will explicitly tell the NIC what DCB settings to use, it is safest to ensure that the NIC is told not to accept such settings from the network switch.

To disable DCBX in the NIC, If you are using a Single Port configuration:

PS> Set-NetQosDcbxSetting NIC1 -Willing $False

If you are using a Dual Port configuration:

PS> Set-NetQosDcbxSetting NIC1,NIC2 -Willing $False

## **Step 3E: Set policy for the rest of the traffic (optional)**

Make sure that all the non-SMB/RDMA traffic goes without a priority tag. While this shouldn’t be necessary because the default priority tag is 0 (untagged), there is no harm in making sure

PS> New-NetQosPolicy "DEFAULT" -Default -PriorityValue8021Action 0

If you want to make sure PFC isn’t on the non-SMB traffic you can actively disable it. This is the default anyway, but better safe than sorry.

PS> Disable-NetQosFlowControl -priority 0,1,2,4,6,7

Before you proceed any further verify with your network switch administrator that the ports on the TOR have been configured with DCB enabled and with PFC on the identified traffic (traffic tagged with “3” in this example). *Appendix 1 has some examples of possible switch/router configurations. Consult your switch/router vendor for details.*

## **Step 3F: Validate your settings (optional)**

While the above steps, if all entered correctly, are all you need, it can be a good idea to validate that you got what you asked for. The commands to check on NetQosFlowControl and NetAdapterQos are:

PS> Get-NetQosFlowControl

Which should return “True” for the priority tags for which you have turned on PFC and “False” for the rest, e.g.,

Priority Enabled PolicySet IfIndex IfAlias

-------- ------- --------- ------- -------

0 False Global

1 False Global

2 False Global

3 True Global

4 False Global

5 False Global

6 False Global

7 False Global

In the Single-port Configuration

PS> Get-NetAdapterQos -Name NIC1

which returns:

Name : NIC1

Enabled : True

Capabilities : Hardware Current

-------- -------

MacSecBypass : NotSupported NotSupported

DcbxSupport : None None

NumTCs(Max/ETS/PFC) : 8/8/8 8/8/8

OperationalTrafficClasses : TC TSA Bandwidth Priorities

-- --- --------- ----------

0 ETS 50% 0-2,4-7

1 ETS 50% 3

OperationalFlowControl : Priority 3 Enabled

OperationalClassifications : Protocol Port/Type Priority

-------- --------- --------

Default 0

NetDirect 445 3

In the Dual-port Configuration

PS> Get-NetAdapterQos -Name NIC1,NIC2

which returns:

Name : NIC1

Enabled : True

Capabilities : Hardware Current

-------- -------

MacSecBypass : NotSupported NotSupported

DcbxSupport : None None

NumTCs(Max/ETS/PFC) : 8/8/8 8/8/8

OperationalTrafficClasses : TC TSA Bandwidth Priorities

-- --- --------- ----------

0 ETS 50% 0-2,4-7

1 ETS 50% 3

OperationalFlowControl : Priority 3 Enabled

OperationalClassifications : Protocol Port/Type Priority

-------- --------- --------

Default 0

NetDirect 445 3

Name : NIC2

Enabled : True

Capabilities : Hardware Current

-------- -------

MacSecBypass : NotSupported NotSupported

DcbxSupport : None None

NumTCs(Max/ETS/PFC) : 8/8/8 8/8/8

OperationalTrafficClasses : TC TSA Bandwidth Priorities

-- --- --------- ----------

0 ETS 50% 0-2,4-7

1 ETS 50% 3

OperationalFlowControl : Priority 3 Enabled

OperationalClassifications : Protocol Port/Type Priority

-------- --------- --------

Default 0

NetDirect 445 3

## **Step 3G: Configure Co-existence with a Debugger**

In Windows Server when a debugger gets attached it interferes with NetQos (DCB). To make this configuration possible the following command must be run:

PS> Set-ItemProperty HKLM:"\SYSTEM\CurrentControlSet\Services\NDIS\Parameters"

AllowFlowControlUnderDebugger -type DWORD -Value 1 –Force

To validate that the Registry Keyword has been created, run:

PS> Get-ItemProperty HKLM:"\SYSTEM\CurrentControlSet\Services\NDIS\Parameters"

| ft AllowFlowControlUnderDebugger

The return should be:

AllowFlowControlUnderDebugger

-----------------------------

1

# Step 4: Test RDMA Connectivity

This step ensures the fabric is correctly configured and works in Native mode (Mode 1) operation. If Mode 1 doesn’t work, Mode 2 and Mode 3 won’t work either.

## **Step 4A: Create the directory C:\TEST**

PS> cd \

PS> mkdir TEST

## **Step 4B: Gather the test tools to make testing easier**

Download the DiskSpd.exe utility and extract into C:\TEST\ . The DiskSpd.exe utility can be found at <https://gallery.technet.microsoft.com/DiskSpd-a-robust-storage-6cd2f223>.

Download the Test-RDMA powershell script to C:\TEST\ . The Test-RDMA script can be found at <https://github.com/Microsoft/SDN/blob/master/Diagnostics/Test-Rdma.ps1>.

## **Step 4C: Ensure the NIC ports have RDMA enabled**

For the Single-port configuration run

PS> Enable-NetAdapterRdma NIC1

For the Dual-port configuration run

PS> Enable-NetAdapterRdma NIC1,NIC2

Confirm that the NICs are now enabled for RDMA.

For the Single-port configuration run

PS> Get-NetAdapterRdma NIC1

The return should look like

Name InterfaceDescription Enabled

---- -------------------- -------

NIC1 Chelsio Network Adapter True

Or perhaps

Name InterfaceDescription Enabled

---- -------------------- -------

NIC1 Mellanox ConnectX-4 VPI Adapter True

For the Dual-port configuration run

PS> Enable-NetAdapterRdma NIC1,NIC2

The return should look like

Name InterfaceDescription Enabled

---- -------------------- -------

NIC1 Chelsio Network Adapter True

NIC2 Chelsio Network Adapter #2 True

Or perhaps

Name InterfaceDescription Enabled

---- -------------------- ------

NIC1 Mellanox ConnectX-4 VPI Adapter True

NIC2 Mellanox ConnectX-4 VPI Adapter #2 True

## **Step 4D: Get the Interface Index and associated IP address of the RDMA NIC(s)**

To get the Interface Index (ifIndex) and IPv4Address associated with your NICs, run:

PS> Get-NetIPConfiguration -InterfaceAlias "NIC\*" |

ft InterfaceAlias,InterfaceIndex,IPv4Address

The return should look like

(Single-port configuration)

InterfaceAlias InterfaceIndex IPv4Address

-------------- -------------- -----------

NIC1 3 {192.168.1.3}

(Dual-port configuration)

InterfaceAlias InterfaceIndex IPv4Address

-------------- -------------- -----------

NIC1 3 {192.168.1.3}

NIC2 7 {192.168.2.3}

## **Step 4E: Check that SMB considers the RDMA interfaces as working**

Now that you have the interface indexes (ifIndexes) of the RDMA-capable NICs, confirm that SMB also sees these interfaces as RDMA-capable.

PS C:\> Get-SmbClientNetworkInterface

Interface Index RSS Capable RDMA Capable Speed IpAddresses

--------------- ----------- ------------ ----- -----------

3 True True 40 Gbps {fe80::e14f:b55:b3dc:b03c, 192.168.1.3}

7 True True 40 Gbps {fe80::9ce6:c07:9aab:d0f4, 192.168.2.3}

If for some reason the RDMA Capable column in the Get-SmbClientNetworkInterface output shows False, it may require a reboot of the host to get SMB to update the value.

## **Step 4F: Test the RDMA connectivity**

Now that you have the local ifIndex, pass the ifIndex value to the Test-RDMA.ps1 script along with the IP address of the remote adapter on the same VLAN. (Reminder: NIC1, IPv4Address 192.168.1.3 is on the same VLAN as NIC1 on the other host which has IPv4Address 192.168.1.5. NIC2, IPv4Address 192.168.2.3 is on the same VLAN as NIC2 on the other host which has IPv4Address 192.168.2.5.)

If we are using RoCE as the RDMA protocol we run

PS> C:\TEST\Test-RDMA.PS1 -IfIndex 3 -IsRoCE $true -RemoteIpAddress 192.168.1.5

-PathToDiskspd C:\TEST\Diskspd-v2.0.17\amd64fre\

The output should resemble this:

VERBOSE: Diskspd.exe found at C:\TEST\Diskspd-v2.0.17\amd64fre\\diskspd.exe

VERBOSE: The adapter NIC1 is a physical adapter

VERBOSE: Underlying adapter is RoCE. Checking if QoS/DCB/PFC is configured on each physical adapter(s)

VERBOSE: QoS/DCB/PFC configuration is correct.

VERBOSE: RDMA configuration is correct.

VERBOSE: Checking if remote IP address, 192.168.1.5, is reachable.

VERBOSE: Remote IP 192.168.1.5 is reachable.

VERBOSE: Disabling RDMA on adapters that are not part of this test. RDMA will be enabled on them later.

VERBOSE: Testing RDMA traffic now for. Traffic will be sent in a parallel job. Job details:

VERBOSE: 0 RDMA bytes written per second

VERBOSE: 0 RDMA bytes sent per second

VERBOSE: 662979201 RDMA bytes written per second

VERBOSE: 37561021 RDMA bytes sent per second

VERBOSE: 1023098948 RDMA bytes written per second

VERBOSE: 8901349 RDMA bytes sent per second

VERBOSE: Enabling RDMA on adapters that are not part of this test. RDMA was disabled on them prior to sending RDMA traffic.

VERBOSE: RDMA traffic test SUCCESSFUL: RDMA traffic was sent to 192.168.1.5

If we are using iWarp as the RDMA protocol we run

PS> C:\TEST\Test-RDMA.PS1 -IfIndex 3 -IsRoCE $false -RemoteIpAddress 192.168.1.5

-PathToDiskspd C:\TEST\Diskspd-v2.0.17\amd64fre\

The output should resemble this:

VERBOSE: Diskspd.exe found at c:\test\diskspd.exe

VERBOSE: The adapter C1 is a pNIC

VERBOSE: RDMA configuration is correct.

VERBOSE: Checking if remote IP address, 192.168.42.100, is reachable.

VERBOSE: Remote IP 192.168.42.100 is reachable.

VERBOSE: Disabling RDMA on adapters that are not part of this test. RDMA will be enabled on them later.

VERBOSE: Testing RDMA traffic now for. Traffic will be sent in a parallel job. Job details:

VERBOSE: 881584596 RDMA bytes written per second

VERBOSE: 30395419 RDMA bytes sent per second

VERBOSE: 916403205 RDMA bytes written per second

VERBOSE: 32782735 RDMA bytes sent per second

VERBOSE: 854809218 RDMA bytes written per second

VERBOSE: 32463001 RDMA bytes sent per second

VERBOSE: 708712636 RDMA bytes written per second

VERBOSE: 37133310 RDMA bytes sent per second

VERBOSE: 855576900 RDMA bytes written per second

VERBOSE: 31471407 RDMA bytes sent per second

VERBOSE: 880404891 RDMA bytes written per second

VERBOSE: 32062793 RDMA bytes sent per second

VERBOSE: 840570441 RDMA bytes written per second

VERBOSE: 32459322 RDMA bytes sent per second

VERBOSE: Enabling RDMA on adapters that are not part of this test. RDMA was disabled on them prior to sending RDMA traffic.

VERBOSE: RDMA traffic test SUCCESSFUL: RDMA traffic was sent to 192.168.42.100

If you are running the dual-port configuration, you should repeat this test with the second pair of NICs just to ensure the switch configuration is correct.

PS> C:\TEST\Test-RDMA.PS1 -IfIndex 7 -IsRoCE $true -RemoteIpAddress 192.168.2.5

-PathToDiskspd C:\TEST\Diskspd-v2.0.17\amd64fre\

If this test fails check to ensure the network switch configuration aligns with the local host configuration.

# Step 5: vSwitch creation and testing of Converged NIC

The next step is to create a vSwitch so that you can test the Converged NIC scenario that is used by e.g., Storage Spaces Direct (S2D). For both configurations we’ll create the vSwitch in Switch Embedded Teaming (SET) mode even though the single NIC configuration doesn’t require teaming.

There are three reasons we create the switch in SET mode:

1. There is no harm to having a team of one NIC;
2. In the single-NIC configuration the administrator may want to add a NIC later (if the switch is not created in SET mode, it can’t be changed to SET mode later); and
3. Most importantly, it simplifies the writing of this guide.

## **Step 5a: Return the local host NICs to a state suitable for use with Hyper-V**

Since we configured VLANs on the local NICs earlier, we will remove those VLANs. The Hyper-V switch requires the NICs to be in promiscuous mode (pass anything), so they can’t have VLANs assigned. VLANs will be assigned at the virtual NIC level later. *Run these on Host A only, not on Host B. We’ll fix the VLANs on Host B later.*

PS> Set-NetAdapterAdvancedProperty -Name NIC1 -RegistryKeyword VlanID

-RegistryValue "0"

In the dual-port configuration also run

PS> Set-NetAdapterAdvancedProperty -Name NIC2 -RegistryKeyword VlanID

-RegistryValue "0"

## **Step 5b: Create a vSwitch on a single NIC**

Create the vSwitch. In the example below we enable three options, two of which can only be enabled at switch creation time. AllowManagementOS creates a host vNIC that we will use to do Converged NIC testing. EnableEmbeddedTeaming allows us to add another NIC to the switch later (for dual port configuration users). EnableIOV will enable us to create a virtual function (VF) in the guest and do Guest RDMA. (If you don’t plan to continue to using Guest RDMA, leave off the -EnableIOV flag.)

PS> New-VMSwitch -Name RTest -NetAdapterName NIC1 -AllowManagementOS $true

-EnableEmbeddedTeaming $true -EnableIov $true

The response should be something like:

Name SwitchType NetAdapterInterfaceDescription

---- ---------- ------------------------------

RTest External Teamed-Interface

## **Step 5c: Configure the Host vNIC for communication with Host B**

The -AllowManagementOS flag on the New-VMSwitch cmdlet resulted in a new virtual adapter (vNIC) in the host partition. The next step is to configure that vNIC to communicate with Host B. Before we do that, however, we need to do a little housekeeping to keep things clear.

The Get-NetAdapter cmdlet shows us the vNIC:

PS> Get-NetAdapter

will return something like:

Name InterfaceDescription ifIndex Status MacAddress LinkSpeed

---- -------------------- ------- ------ ---------- ---------

vEthernet (RTEST) Hyper-V Virtual Ethernet Adapter 27 Up E4-1D-2D-07-40-71 40 Gbps

A Host vNIC is managed two ways: one representation is the NetAdapter view which operates on the "vEthernet (RTEST)" Name, the other mechanism is the VMNetworkAdapter view which drops the "vEthernet" prefix and simply uses the vSwitch name. The VMNetworkAdapter view allows for setting some vNIC properties that are not accessible via the NetAdapter view.

PS> Get-VMNetworkAdapter -ManagementOS

which will return something like

Name IsManagementOs VMName SwitchName MacAddress Status IPAddresses

---- -------------- ------ ---------- ---------- ------ -----------

RTEST True RTEST E41D2D074071 {Ok}

The first vNIC exposed in the host partition is traditionally used for management (e.g., remote access, etc.) while this guide is setting up the host to use RDMA from the host. While we could work with having the interface name the same as the switch name, it’s more convenient to rename the host vNIC to a meaningful name.

PS> Rename-VMNetworkAdapter -ManagementOS -VMNetworkAdapterName Mgmt

Since we want to use a vNIC to carry SMB traffic, we create a new vNIC for that.

PS> Add-VMNetworkAdapter -ManagementOS -VMNetworkAdapterName SMB1

Let’s review what the host vNICs are now:

PS> Get-VMNetworkAdapter -ManagementOS

The ooutput should look like:

Name IsManagementOs VMName SwitchName MacAddress Status IPAddresses

---- -------------- ------ ---------- ---------- ------ -----------

Mgmt True Rtest 00155D579802 {Ok}

SMB1 True Rtest 00155D579803 {Ok}

Since the Get-NetAdapter and Get-VMNetworkAdapter cmdlet families report different names for these vNIC interfaces, it simplifies our lives to make them identical. We rename the Get-NetAdapter view of the vNICs.

PS> Rename-NetAdapter "\*Mgmt\*" Mgmt

PS> Rename-NetAdapter "\*SMB1\*" SMB1

Verify the name changes worked as expected:

PS> Get-NetAdapter

Name InterfaceDescription ifIndex Status MacAddress LinkSpeed

---- -------------------- ------- ------ ---------- ---------

SMB1 Hyper-V Virtual Ethernet Adapter #2 7 Up 00-15-5D-57-98-03 40 Gbps

Mgmt Hyper-V Virtual Ethernet Adapter 9 Up 00-15-5D-57-98-02 40 Gbps

Finally, let’s assign the IP addresses we want to the host vNICs: a new one to the Mgmt interface, and the one we were using already to the SMB interface.

PS> New-NetIPAddress -InterfaceAlias Mgmt -IPAddress 192.168.1.2 -PrefixLength 24

PS> New-NetIPAddress -InterfaceAlias SMB1 -IPAddress 192.168.1.3 -PrefixLength 24

Finally, we need to add the VLAN tag back to the SMB interface so it can communicate with the Host B network adapter.

PS> Set-VMNetworkAdapterIsolation -ManagementOS -VMNetworkAdapterName SMB1

-IsolationMode Vlan -DefaultIsolationID 101

At the end of this step the configuration of the hosts looks like one of the figures below:

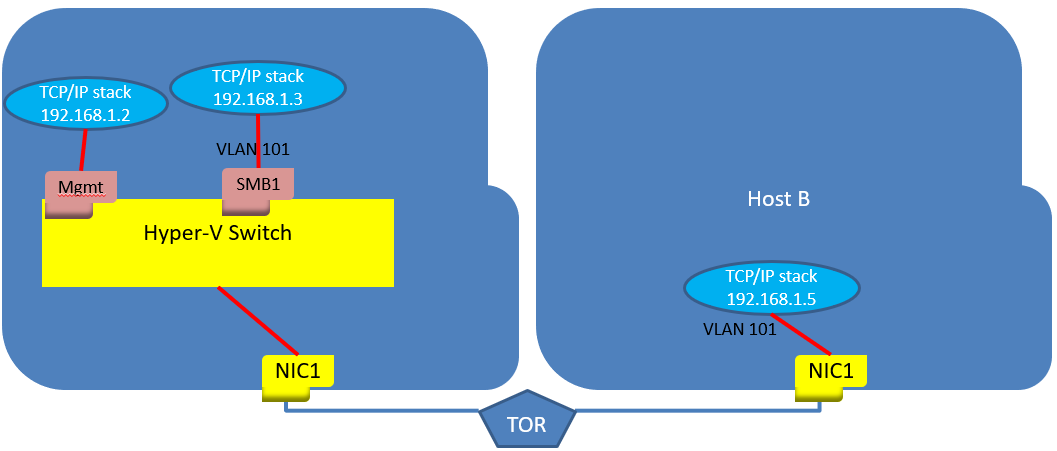


Figure 5 - After switch creation (single-port configuration)

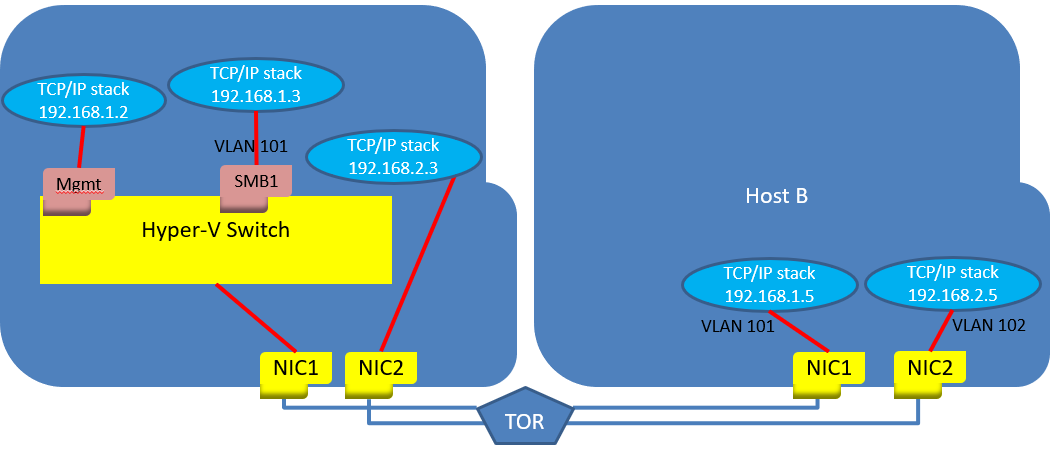


Figure 6 - After switch creation (dual-port configuration)

## **Sidenote on VLAN management in Windows Server 2016 and Windows Server 1709**

In Windows Server 2016 the VLAN assigned to the physical NIC is not copied to the host vNIC when the switch was created. As of Windows Server 1709 the VLAN is copied to the host vNIC when the switch is created. Either way, since we removed the VLANs from the physical hosts in step 6a you need to assign the VLAN value to the host vNIC. Let’s first check to see whether or not the VLAN is assigned.

Unfortunately, Windows Server stores VLAN information in two different places and using the wrong cmdlet will cause you to see incorrect information. To get a complete picture, you need to run two different cmdlets:

PS> Get-VMNetworkAdapterVlan -ManagementOS

PS> Get-VMNetworkAdapterIsolation -ManagementOS

As an example, if we set the VLAN using Set-VMNetworkAdapterIsolation and then use Get-VMNetworkAdapterVlan we will see incorrect information. To wit, here is a three cmdlet sequence:

# Set the VLAN for host vNIC to value 101

PS C:\WINDOWS\system32> set-VMNetworkAdapterIsolation -ManagementOS -IsolationMode Vlan

-DefaultIsolationID 101

# Check the value using Get-VMNetworkAdapterVlan

PS C:\WINDOWS\system32> Get-VMNetworkAdapterVlan -ManagementOS

VMName VMNetworkAdapterName Mode VlanList

------ -------------------- ---- --------

SMB1 Untagged

# Previous cmdlet says traffic is untagged, but now check with Get-VMNetworkAdapterIsolation

PS C:\WINDOWS\system32> Get-VMNetworkAdapterIsolation -ManagementOS

IsolationMode : Vlan

AllowUntaggedTraffic : False

DefaultIsolationID : 101

MultiTenantStack : Off

ParentAdapter : VMInternalNetworkAdapter, Name = 'SMB1'

IsTemplate : False

# With this cmdlet the vNIC reports it has a VLAN assigned

The good thing is that it doesn’t matter whether you use Set-VMNetworkAdapterVlan or Set-VMNetworkAdapterIsolation as they both work (except when the SDN-extension is used). But if you want to change or remove the VLAN you **must** use the same cmdlet family you used to assign the VLAN. (The recommended cmdlet family for VLAN management is the VMNetworkAdapterIsolation cmdlets since they work in all configurations.)

Check for the presence of a VLAN on the host vNIC. If the correct one (VLAN 101 in our example) isn’t present, add it using Set-VMNetworkAdapterIsolation as shown below:

PS> set-VMNetworkAdapterIsolation -ManagementOS -IsolationMode Vlan

-DefaultIsolationID 101

## **Step 5d: Test TCP-IP connectivity using the Host vNIC**

Since we removed the pNIC’s VLAN setting and added the vNIC’s VLAN setting, we should make sure we can still communicate.

PS> Test-NetConnection 192.168.1.5

ComputerName : 192.168.1.5

RemoteAddress : 192.168.1.5

InterfaceAlias : vEthernet (GuestRdma)

SourceAddress : 192.168.1.3

PingSucceeded : True

PingReplyDetails (RTT) : 0 ms

Observe the result to make sure that “PingSucceeded” shows “True”. If it doesn’t show “True”, check the VLAN settings of the pNIC and the vNIC to make sure they were administered correctly (pNIC should have no VLAN set, vNIC should be set to 101).

PS C:\test> Get-NetAdapterAdvancedProperty NIC1 |ft VLANID

VLANID

------

(*blank line)*

PS> Get-VMNetworkAdapterIsolation -ManagementOS

IsolationMode : None

AllowUntaggedTraffic : False

DefaultIsolationID : 101

MultiTenantStack : Off

ParentAdapter : VMInternalNetworkAdapter, Name = 'SMB1'

IsTemplate : True

IsolationMode : None

AllowUntaggedTraffic : False

DefaultIsolationID : 0

MultiTenantStack : Off

ParentAdapter : VMInternalNetworkAdapter, Name = 'Mgmt'

IsTemplate : True

## **Step 5e: Test RDMA connectivity using the Host vNIC**

If you check the Host vNIC now to see if it is configured for RDMA, the answer will probably be False. I.e.,

PS> Get-NetAdapterRdma SMB1

should return something like:

Name InterfaceDescription Enabled

---- -------------------- -------

SMB1 Hyper-V Virtual Ethernet Adapter False

To enable the vNIC for RDMA operation, enable RDMA:

PS> Enable-NetAdapterRdma \*SMB1\*

Check the result by running the Get-NetAdapterRdma cmdlet again:

PS> Get-NetAdapterRdma \*SMB1\*

should now return:

Name InterfaceDescription Enabled

---- -------------------- -------

SMB1 Hyper-V Virtual Ethernet Adapter True

Now we can test the vNIC to see if RDMA is working with Host B.

Get the ifIndex of the vNIC:

PS> Get-NetAdapter

should return something like we saw in step 6c:

Name InterfaceDescription ifIndex Status MacAddress LinkSpeed

---- -------------------- ------- ------ ---------- ---------

SMB1 Hyper-V Virtual Ethernet Adapter 27 Up E4-1D-2D-07-40-71 40 Gbps

We know the Host B NIC is configured with IPv4Address 192.168.1.5.

If we are running with RoCE as the RDMA protocol, we run:

PS> C:\TEST\Test-RDMA.PS1 -IfIndex 27 -IsRoCE $true -RemoteIpAddress 192.168.1.5

-PathToDiskspd C:\TEST\Diskspd-v2.0.17\amd64fre\

If all the configuration was correct we should see:

PathToDiskspd C:\TEST\Diskspd-v2.0.17\amd64fre\

VERBOSE: Diskspd.exe found at C:\TEST\Diskspd-v2.0.17\amd64fre\\diskspd.exe

VERBOSE: The adapter vEthernet (RTEST) is a virtual adapter

VERBOSE: Retrieving vSwitch bound to the virtual adapter

VERBOSE: Found vSwitch: RTEST

VERBOSE: Found the following physical adapter(s) bound to vSwitch: M1

VERBOSE: Underlying adapter is RoCE. Checking if QoS/DCB/PFC is configured on each physical adapter(s)

VERBOSE: QoS/DCB/PFC configuration is correct.

VERBOSE: RDMA configuration is correct.

VERBOSE: Remote IP 192.168.1.5 is reachable.

VERBOSE: Disabling RDMA on adapters that are not part of this test. RDMA will be enabled on them later.

VERBOSE: Testing RDMA traffic now for. Traffic will be sent in a parallel job. Job details:

VERBOSE: 9162492 RDMA bytes sent per second

VERBOSE: 938797258 RDMA bytes written per second

VERBOSE: 34621865 RDMA bytes sent per second

VERBOSE: 933572610 RDMA bytes written per second

VERBOSE: 35035861 RDMA bytes sent per second

VERBOSE: Enabling RDMA on adapters that are not part of this test. RDMA was disabled on them prior to sending RDMA traffic.

VERBOSE: RDMA traffic test SUCCESSFUL: RDMA traffic was sent to 192.168.1.5

If we are running with iWarp as the RDMA protocol we run:

PS> C:\TEST\Test-RDMA.PS1 -IfIndex 27 -IsRoCE $false -RemoteIpAddress 192.168.1.5

-PathToDiskspd C:\TEST\Diskspd-v2.0.17\amd64fre\

VERBOSE: Diskspd.exe found at c:\test\Diskspd-v2.0.17\amd64fre\diskspd.exe

VERBOSE: The adapter SMB1 is a vNIC

VERBOSE: Retrieving vSwitch bound to the virtual adapter

VERBOSE: Found vSwitch: Rtest

VERBOSE: Found the following physical adapter(s) bound to vSwitch: C1

VERBOSE: RDMA configuration is correct.

VERBOSE: Remote IP 192.168.1.5 is reachable.

VERBOSE: Disabling RDMA on adapters that are not part of this test. RDMA will be enabled on them later.

VERBOSE: Testing RDMA traffic. Traffic will be sent in a background job. Job details:

VERBOSE: 854055239 RDMA bytes written per second

VERBOSE: 32234131 RDMA bytes sent per second

VERBOSE: 860933980 RDMA bytes written per second

VERBOSE: 30619357 RDMA bytes sent per second

VERBOSE: 861202064 RDMA bytes written per second

VERBOSE: 27255016 RDMA bytes sent per second

VERBOSE: Enabling RDMA on adapters that are not part of this test. RDMA was disabled on them prior to sending RDMA traffic.

SUCCESS: RDMA traffic test SUCCESSFUL: RDMA traffic was sent to 192.168.1.5

## **Step 5f: (Dual-port configuration) Add and test the second port**

Now that the single-port configuration is working we can add the second port.

To add a NIC to a SET team, use Add-VMSwitchTeamMember. (Information about managing Switch Embedded Teams can be found in section 4.2 of the Windows Server 2016 NIC and Switch Embedded Teaming User Guide found at <https://gallery.technet.microsoft.com/Windows-Server-2016-839cb607>.

PS> Add-VMSwitchTeamMember -VMSwitchName RTEST -NetAdapterName NIC2

Having two pNICs in the team is interesting, but to test RDMA on both we also need an additional host vNIC for SMB to use in SMB-Multichannel mode. We will add a vNIC names “SMB2”, assign the IP address that was used on NIC2 earlier in this exercise, and tag it with VLAN value of 102.

PS> Add-VMNetworkAdapter -ManagementOS -Name SMB2

PS> New-NetIPAddress -InterfaceAlias SMB2 -IPAddress 192.168.1.4

PS> Set-VMNetworkAdapterVlan -VMNetworkAdapterName SMB2 -VlanId "101" -Access

-ManagementOS

For best performance map the two SMB vNICs to the two pNICs. Since affinities between vNICs and physical NIC resources are random when the operating systems chooses them, it’s best to override the random assignment and make sure the two SMB interfaces don’t end up mapped to the same underlying pNIC.

PS> Set-VMNetworkAdapterTeamMapping -ManagementOS -VMNetworkAdapterName SMB1

-PhysicalNetAdapterName NIC1

PS> Set-VMNetworkAdapterTeamMapping -ManagementOS -VMNetworkAdapterName SMB2

-PhysicalNetAdapterName NIC2

Again we need to get the ifIndex of the new vNIC:

PS> Get-NetAdapter

should return something like we saw in step 6c:

Name InterfaceDescription ifIndex Status MacAddress LinkSpeed

---- -------------------- ------- ------ ---------- ---------

vEthernet (SMB1) Hyper-V Virtual Ethernet Adapter 27 Up E4-1D-2D-07-40-71 40 Gbps

vEthernet (SMB2) Hyper-V Virtual Ethernet Adapter 41 Up E4-1D-2D-07-40-72 40 Gbps

Now we can test to see if the new interface is also working for RDMA traffic.

PS> C:\TEST\Test-RDMA.PS1 -IfIndex 41 -IsRoCE $false -RemoteIpAddress 192.168.1.5

-PathToDiskspd C:\TEST\Diskspd-v2.0.17\amd64fre\

The results should resemble those in step 6E.

# Step 6 – Enabling SR-IOV for Guest RDMA

Guest RDMA is only supported starting in Windows Server 1709. The following steps will not work on any earlier edition of Windows Server.

## **Step 6A – Update the Network Card Drivers on the Host**

Since none of the inbox drivers in Windows Server 1709 support Guest RDMA, you need to download and install the latest drivers from your network card vendor. Make sure the release notes for the driver you install indicates support for Guest RDMA. Once the new drivers are installed we can proceed. A reboot may be necessary as part of driver installation.

When you have installed the latest drivers, confirm they are installed by running:

PS>Get-NetAdapter NIC1 | fl

and check that the driver version indicated is the one you thought you were installing.

## **Step 6B – Enable SR-IOV on the Host Adapters**

Back in Step 5B we created a Hyper-V switch and we told the system that -IovEnabled was $true. So we have SR-IOV enabled in the vSwitch already. Now we need to create a VM and make it SR-IOV and RDMA capable. Before we do that let’s make sure the adapter(s) that are bound to the vSwitch have SR-IOV turned on.

To turn on SR-IOV in the single NIC Port configuration:

PS> Enable-NetAdapterSriov NIC1

To turn on SR-IOV in the dual NIC Port configuration:

PS> Enable-NetAdapterSriov NIC1,NIC2

## **Step 6C – Create and start a VM**

Before you can create the VM you need to put a VHDX in a known location for the VM to use. The most common place is in the default directory: c:\Users\Public\Public Documents\Hyper-V\Virtual hard disks\. For ease of referencing it later, name it VM1.vhdx.

Now we can create the VM.

PS> new-vm VM1 -Generation 2 -switchname RTest -vhdpath

"C:\users\public\documents\hyper-v\virtual hard disks\VMl.vhdx

Before we start the VM we need to set the VM’s network interface into SR-IOV and RDMA-capable mode.

PS> set-VMNetworkAdapter VM1 -IovWeight 100 -IovQueuePairsRequested 8 #enable IOV

PS> set-VMNetworkAdapterRdma VM1 -RdmaWeight 100 #enable RDMA

Now we can start the VM:

PS> start-VM VM1

## **Step 6D – Log into the VM and complete the Out-of-Box (OOB) Experience**

Log into the VM and complete the initial settings for language, etc. For the purpose of this guide we’ll assume you know how to do that.

Give your guest network interface an IP address in the same space as your host management vNIC:

PS> Net-NetIPAddress -IPAddress 192.168.1.10 -PrefixLength 24 -InterfaceAlias Ethernet

## **Step 6E – Copy the network drivers into the VM**

Since the inbox drivers for Windows Server 1709 do not support Guest RDMA, you must get the latest drivers from the network adapter vendor and install them in the guest. Follow the guidance of your network vendor.

*By default, if the network driver in the host supports SR-IOV, then when the guest becomes SR-IOV enabled the host will copy the driver to the guest for you. If in doubt, check to make sure the driver you are running for the VF is the latest available.*

Once everything is installed running Get-NetAdapter in the guest should show (Chelsio example):

PS> Get-NetAdapter

should return

Name Interface Description ifIndex Status MacAddress LinkSpeed

---- --------------------- ------- ------ ---------- ---------

Ethernet Microsoft Hyper-V Network Adapter 2 Up 00-15-5D-2A-63-00 40 Gbps

Ethernet 2 Chelsio VF Network Adapter 7 Up 00-15-5D-2A-63-00 7 Gbps

## **Step 6F – test connectivity**

Now that the VF is installed in the VM, let’s test connectivity to Host B.

PS> Test-NetConnection 192.168.1.5

ComputerName : 192.168.1.5

RemoteAddress : 192.168.1.5

InterfaceAlias : Ethernet

SourceAddress : 192.168.1.10

PingSucceeded : True

PingReplyDetails (RTT) : 0 ms

# Step 7 – Enabling Guest RDMA

## **Step 7A – Enable the vmNIC for RDMA**

Inside the guest, enable RDMA on the vmNIC and VF:

PS> Enable-NetAdapterRdma Ethernet,”Ethernet 2”

Check to see that it worked.

PS> Get-NetAdapterRdma

Name Interface Description Enabled

---- --------------------- -------

Ethernet 2 Chelsio VF Network Adapter True

Ethernet Microsoft Hyper-V Network Adapter True

Now use Get-NetAdapter one more time to get the Interface Indexes (IfIndex) of the adapter and the VF.

PS> Get-NetAdapter

Name Interface Description ifIndex Status MacAddress LinkSpeed

---- --------------------- ------- ------ ---------- ---------

Ethernet Microsoft Hyper-V Network Adapter 2 Up 00-15-5D-2A-63-00 40 Gbps

Ethernet 2 Chelsio VF Network Adapter 7 Up 00-15-5D-2A-63-00 7 Gbps

## **Step 7B – Test Guest RDMA**

The Test-Rdma script has an additional parameter for testing in the guest. Specifically, it needs the IfIndex of the VF (Parameter: VFIndex). *Note: In the guest the “IsRoCE” flag is ignored and can be set to any value.*

PS> C:\TEST\Test-RDMA.PS1 -IfIndex 3 -IsRoCE $false -RemoteIpAddress 192.168.1.5

-PathToDiskspd C:\TEST\Diskspd-v2.0.17\amd64fre\ -VFIndex 2

The output should resemble:

VERBOSE: Diskspd.exe found at c:\test\Diskspd-v2.0.17\amd64fre\diskspd.exe

VERBOSE: The adapter SMB1 is a vNIC

CAUTION: Guest Virtual NIC being tested, Guest can't check host adapter settings.

VERBOSE: Retrieving vSwitch bound to the virtual adapter

VERBOSE: Found vSwitch: Rtest

VERBOSE: Found the following physical adapter(s) bound to vSwitch: C1

VERBOSE: RDMA configuration is correct.

VERBOSE: Remote IP 192.168.1.5 is reachable.

VERBOSE: Disabling RDMA on adapters that are not part of this test. RDMA will be enabled on them later.

VERBOSE: Testing RDMA traffic. Traffic will be sent in a background job. Job details:

VERBOSE: 854055239 RDMA bytes written per second

VERBOSE: 32234131 RDMA bytes sent per second

VERBOSE: 860933980 RDMA bytes written per second

VERBOSE: 30619357 RDMA bytes sent per second

VERBOSE: 861202064 RDMA bytes written per second

VERBOSE: 27255016 RDMA bytes sent per second

VERBOSE: Enabling RDMA on adapters that are not part of this test. RDMA was disabled on them prior to sending RDMA traffic.

SUCCESS: RDMA traffic test SUCCESSFUL: RDMA traffic was sent to 192.168.1.5

# Appendix 1: Physical Switch DCB Configuration Examples

In the table below are some example network switch configurations for use with RoCE deployments. Consult your switch vendor for additional assistance.

## **Arista switch (dcs-7050s-64, EOS-4.13.7M)**

These are only commands and their uses; admins need to determine which ports the NICs are connected to.

Ensure that VLAN and no-drop policy is set for the priority over which SMB is configured.

1. en (go to admin mode, usually asks for a password)
2. config (to enter into configuration mode)
3. show run (shows current running configuration)
4. find out switch ports to which your NICs are connected to. In these example, they are 14/1,15/1,16/1,17/1.
5. int eth 14/1,15/1,16/1,17/1 (enter into config mode for these ports)
6. dcbx mode ieee
7. priority-flow-control mode on
8. switchport trunk native vlan 225
9. switchport trunk allowed vlan 100-225
10. switchport mode trunk
11. priority-flow-control priority 3 no-drop
12. qos trust cos
13. show run (verify that configuration is setup correctly on the ports)
14. wr (to make the settings persists across switch reboot)

**Tips:**

1. No #command# negates a command
2. How to add a new VLAN: int vlan 100 (If storage network is on VLAN 100)
3. How to check existing VLANs : show vlan
4. For more information on configuring Arista Switch, search online for: Arista EOS Manual
5. Use this command to verify PFC settings: show priority-flow-control counters detail

## **Dell switch (S4810, FTOS 9.9 (0.0))**

!

dcb enable

! put pfc control on qos class 3

configure

dcb-map dcb-smb

priority group 0 bandwidth 90 pfc on

priority group 1 bandwidth 10 pfc off

priority-pgid 1 1 1 0 1 1 1 1

exit

! apply map to ports 0-31

configure

interface range ten 0/0-31

dcb-map dcb-smb

exit

## **Cisco switch (Nexus 3132, version 6.0(2)U6(1))**

**Global:**

class-map type qos match-all RDMA

match cos 3

class-map type queuing RDMA

match qos-group 3

policy-map type qos QOS\_MARKING

class RDMA

set qos-group 3

class class-default

policy-map type queuing QOS\_QUEUEING

class type queuing RDMA

bandwidth percent 50

class type queuing class-default

bandwidth percent 50

class-map type network-qos RDMA

match qos-group 3

policy-map type network-qos QOS\_NETWORK

class type network-qos RDMA

mtu 2240

pause no-drop

class type network-qos class-default

mtu 9216

system qos

service-policy type qos input QOS\_MARKING

service-policy type queuing output QOS\_QUEUEING

service-policy type network-qos QOS\_NETWORK

**Port specific:**

switchport mode trunk

switchport trunk native vlan 99

switchport trunk allowed vlan 99,2000,2050   çuse VLANs that already exists

spanning-tree port type edge

flowcontrol receive on (not supported with PFC in Cisco NX-OS)

flowcontrol send on (not supported with PFC in Cisco NX-OS)

no shutdown

priority-flow-control mode on

# Appendix 2: Tools that may help

In addition to the tools mentioned at **Step 4B: Gather the test tools to make testing easier**, the following tools may assist in configuring switches and NICs for RDMA:

1. The sample Switch configuration scripts found at <https://github.com/Microsoft/SDN/tree/master/SwitchConfigExamples>
2. The Mellanox RDMA community page found at <https://community.mellanox.com/docs/DOC-2283>
3. The User Guides and Release Notes for your vendor. As of this writing every major Server NIC vendor (alphabetically: Broadcom, Cavium-QLogic, Chelsio, Cisco, Intel, and Mellanox) is shipping an RDMA solution. At least three have working Guest RDMA solutions that work with Windows Server 1709.