Using Intel® Ethernet and the PCI-SIG* Single Root I/O Virtualization (SR-IOV) and Sharing Specification on Red Hat* Enterprise Linux*

Technical Brief v1.0

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1.0 Introduction

Processor and platform advances, along with progress in operating systems and applications, have spurred data centers to quickly adopt 10 Gigabit Ethernet (10 GbE) as the standard for interconnects. The Intel® Ethernet Server Adapter X520 family of adapters introduces numerous industry-leading features that are helping data center administrators implement innovative solutions for difficult and challenging connectivity problems. I/O Virtualization is one of the fastest growing usage models within the data center. The X520 family of adapters provides the ability to create Virtual Functions (VFs) that are identical instantiations of the Physical Functions (PFs). VFs are capable of providing 10 GbE connectivity to Virtual Machines (VMs) within a virtualized operating system framework. This document shows how to make use of these VFs using Linux® KVM*, which is an integral part of Red Hat® Enterprise Linux® version 6 and 6.1.

1.1 Hardware Requirements

- An Intel® Ethernet X520 Server Adapter
- A server platform that supports Intel® Virtualization Technology for Directed I/O (VT-d) and the PCI-SIG* Single Root I/O Virtualization and Sharing (SR-IOV) specification
- A server platform with an available PCI Express*:X8 5.0Gb/s (Gen2) slot

1.2 Software Requirements

Red Hat Enterprise Linux Version 6.0 or 6.1

2.0 Installation and Configuration

1. Install the Intel® Ethernet X520 server adapter in an available PCI-Express x8 slot. (Ensure that the x8 slot is electrically connected as a x8, some slots are physically x8 but electrically support only x4. Verify this with your server manufacturer or system documentation.)

2. Power up the server.

3. Enter the server’s BIOS setup and make sure the virtualization technology and Intel® VT-d features are enabled.

4. Install Red Hat Enterprise Linux 6 or 6.1 on the server.

5. Make sure all Linux KVM modules, libraries, user tools, and utilities have been installed during the operation system installation.

6. The Red Hat Enterprise Linux installation process may require a server reboot upon successful operating system install.

7. Log in to the newly-installed Red Hat Enterprise Linux operating system using the “root” user account and password.

I/O Memory Management Unit (IOMMU) support is not enabled by default in Red Hat Enterprise Linux 6.0 or 6.1 distributions. IOMMU support is required for a VF to function properly when assigned to a VM. The following kernel boot parameters are required to enable IOMMU support for Linux kernels:

```
intel_iommu=on
```
These parameters can be appended to the kernel boot entry in /boot/grub/menu.lst configuration file. See Figure 1.

1. Reboot the server for the iommu change to take effect.
2. PF and VF drivers for the X520 server adapter are included in Red Hat Enterprise Linux 6.x distributions and are named as ixgbe and ixgbevf respectively.
3. The Red Hat Enterprise Linux 6.x installation does not create VF by default. The X520 server adapter supports up to 63 VFs per port. VFs can be created by using the ixgbe driver load time parameter called max_vfs. The example below (Figure 2) shows the creation of four VFs per port.

#modprobe ixgbe max_vfs=4

Warnings, errors and informational messages during ixgbe driver load are logged in the /var/log/messages file. It is good practice to review this file to confirm that the driver loaded successfully without warnings or errors.

4. Use the lspci command to confirm that the VF was successfully created. Example entry:

   #lspci | grep 82599

See the following, Figure 3, for the result of this command.
Figure 3 shows four VFs per port for the X520 server adapter. Each VF is identified by an unique bus, device and function number. In the example, the first VF is assigned Bus #7, Device #10 Function #0. VFs ending with an even function number belong to PF 0, that is port 0. VFs ending with an odd function number belong to PF 1, that is port 1.

Module options are not persistent from one boot to next. Create the `ixgbe.conf` file in the `/etc/modprobe.d/` folder to ensure the user-defined number of VFs are created during server boot time. See Figure 4.

Upon successful VF creation, the Linux operating system will load the `ixgbevf` driver automatically. In Linux operating systems, the user can prevent a driver from loading by "blacklisting" the driver. To prevent the `ixgbevf` driver from loading at VF creation time, add the following entry to the `blacklist.conf` file, which is located in the `/etc/modprobe.d/` directory. See Figure 5.

```
blacklist ixgbevf
```
During the creation of user-defined number of VFs, ixgbe driver assigns a random MAC address to each VF. The MAC addresses may change from one boot to the next. The Linux `iproute` utility is used to assign a user-defined MAC address to each VF. Check
that each VF is assigned a unique MAC address; duplicate MAC addresses will cause loss of communication on the network. Use the command shown below to set a MAC address for each VF.

```
# ip link set eth3 vf 0 mac aa:bb:cc:dd:ee:ff
```

Use the command shown below to confirm that the VF MAC address assignment was completed successfully. Figure 6 shows an example of the results of this command.

```
# ip link show eth2
```

To ensure each VF carries the same MAC address assignment from one boot to next, the commands from the previous step can be appended to `rc.local` file, which is located in the `/etc/rc.d/` directory. The Linux OS executes the `rc.local` script at the end of the boot process. See the example Figure 7.
Red Hat Enterprise Linux 6.x includes tools for creating and managing VMs. These tools offer both Command Line (CLI) and Graphical User (GUI) interfaces. Virt-Manager is a GUI tool for creating and managing VMs.

1. Use virt-manager to create a VM.

2. Install the operating system of choice on the newly created VM. For the purpose of this document, Fedora 15 32-Bit desktop Linux was installed in the VM. See example below:

```
[root@rhel61sm1 ~]# cd /etc/rc.d
[root@rhel61sm1 rc.d]# ls
[root@rhel61sm1 rc.d]# cat rc.local
#!/bin/sh
#
# This script will be executed *after* all the other init scripts.
# You can put your own initialization stuff in here if you don't
# want to do the full Sys V style init stuff.

touch /var/lock/subsys/local
ip link set eth2 vf 0 mac 00:ba:df:ac:e0:00
ip link set eth2 vf 1 mac 00:ba:df:ac:e0:01
ip link set eth3 vf 0 mac 00:ba:df:ac:e0:02
ip link set eth3 vf 1 mac 00:ba:df:ac:e0:03
[root@rhel61sm1 rc.d]# 
```

Guest not running
3. Click on the “I” icon to edit the VM properties.
4. Click on the “Add Hardware” icon to start the "Add new virtual hardware" wizard, as shown in Figure 10.
5. Click “PCI Host Device” to start the “Add new virtual hardware” window; see Figure 11.

6. Select an Intel Ethernet X520 Virtual Function and click on the Finish button. In Figure 11, the Intel Ethernet X520 virtual function is listed as “82599 Ethernet Controller Virtual Function”. One or more VFs can be assigned to a VM. Upon successful assignment, the VM is ready to use.

7. Power up the Fedora 15 VM. Log into the VM using the credentials created during the VM installation process.
8. Open the Linux Terminal. Use the Linux `lspci` utility to confirm that the assigned VF is shown within the VM's PCI-Express hierarchy. See Figure 12.
9. Use the Linux `lsmod` utility to confirm that the driver for the VF has loaded successfully, as shown in Figure 13.
10. Use the Linux `ifconfig` utility to confirm that the newly assigned VF is ready for use (Figure 14).

The VF can be configured for dynamic HCP or static IP address assignment. The VF is ready to communicate once it has an IP address assigned.

3.0 Summary

Intel's best-of-breed 10 GbE solutions are now available with I/O Virtualization capabilities. Customers get world-class Ethernet support along with I/O virtualization support in mainstream Linux distributions in a single adapter.

4.0 Customer Support

Intel® Customer Support Services offers a broad selection of programs including phone support and warranty service. For more information, contact us at:

support.intel.com/support/go/network/ adapter/home.htm
(Service and availability may vary by country.)

5.0 **For Product Information**

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