VI3 Networking Scenarios and Troubleshooting

Krishna Raj Raja

VMware

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Why This Talk ?

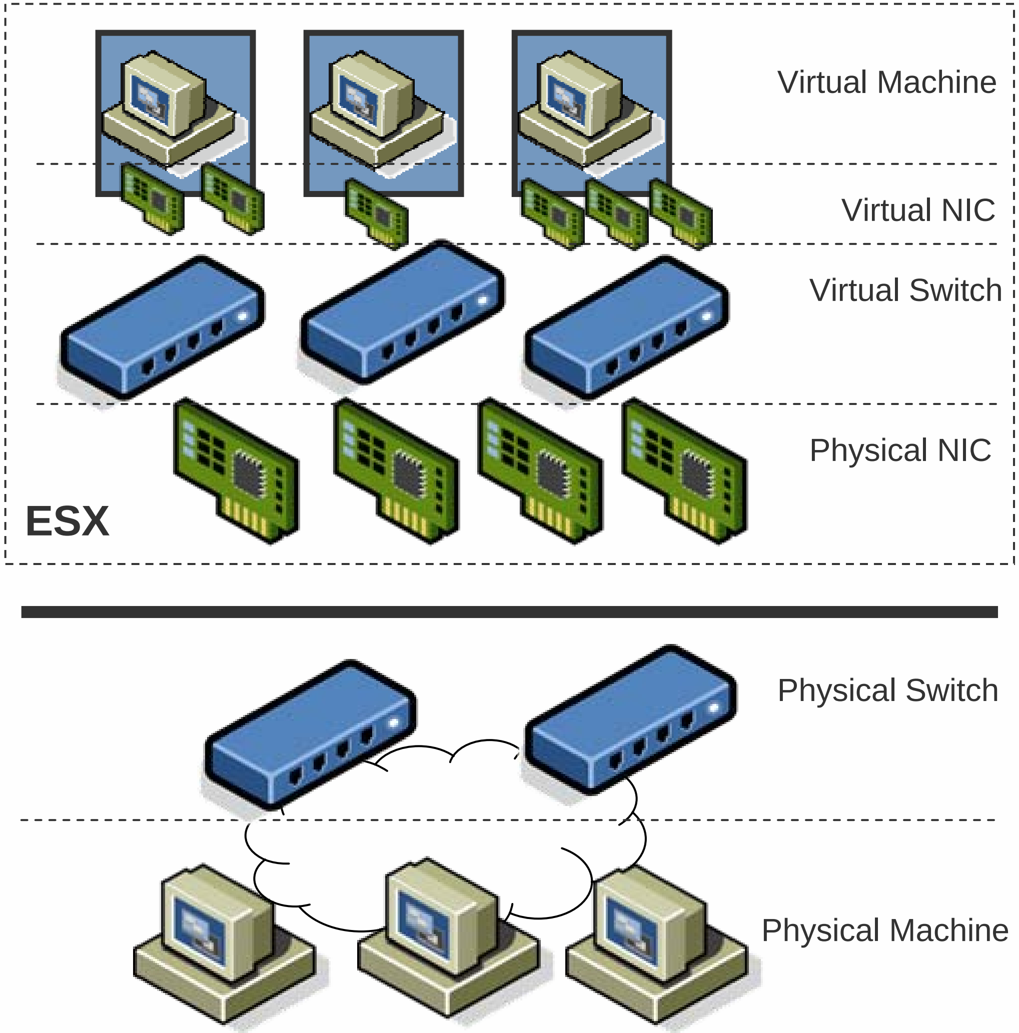
- A vast majority of networking problems are configuration issues with the physical switch
- Physical switches are managed by network administrators. Virtual switches are under the control of ESX administrators
- Enabling/disabling various networking features can have subtle or drastic implications on your network connectivity
- Knowledge on how virtual switch works helps to troubleshoot problems

Outline

- ESX Networking details
- Scenarios
  - Virtual Switch boundaries
  - VLAN
  - Layer 2 Security
  - Load Balancing
  - Failover
- Diagnostics

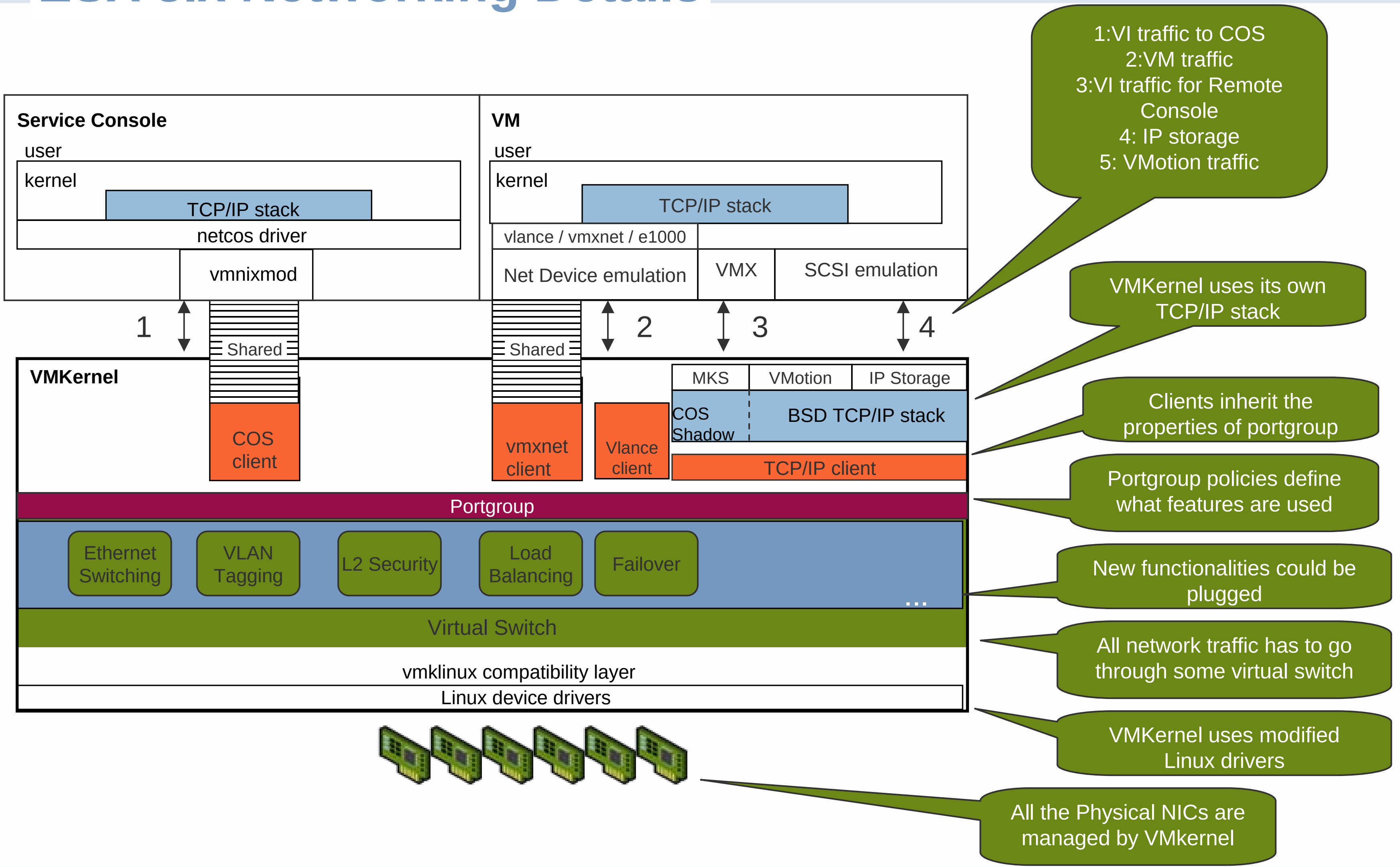
- This talk assumes familiarity with ESX networking features

ESX Networking: Logical Layout



- Multiple layers, multiple ways to interconnect
- Interesting possibilities !

ESX 3.x Networking Details



Service Console

user

kernel

TCP/IP stack

netcos driver

vmnixmod

VM

user

kernel

TCP/IP stack

vlance / vmxnet / e1000

Net Device emulation

VMX

SCSI emulation

1 2 3 4

Shared

Shared

VMKernel

COS client

vmxnet client

Vlance client

MKS

VMotion

IP Storage

COS Shadow

BSD TCP/IP stack

TCP/IP client

Portgroup

Ethernet Switching

VLAN Tagging

L2 Security

Load Balancing

Failover

...

Virtual Switch

vmklinux compatibility layer

Linux device drivers

1:VI traffic to COS
2:VM traffic
3:VI traffic for Remote Console
4: IP storage
5: VMotion traffic

VMKernel uses its own TCP/IP stack

Clients inherit the properties of portgroup

Portgroup policies define what features are used

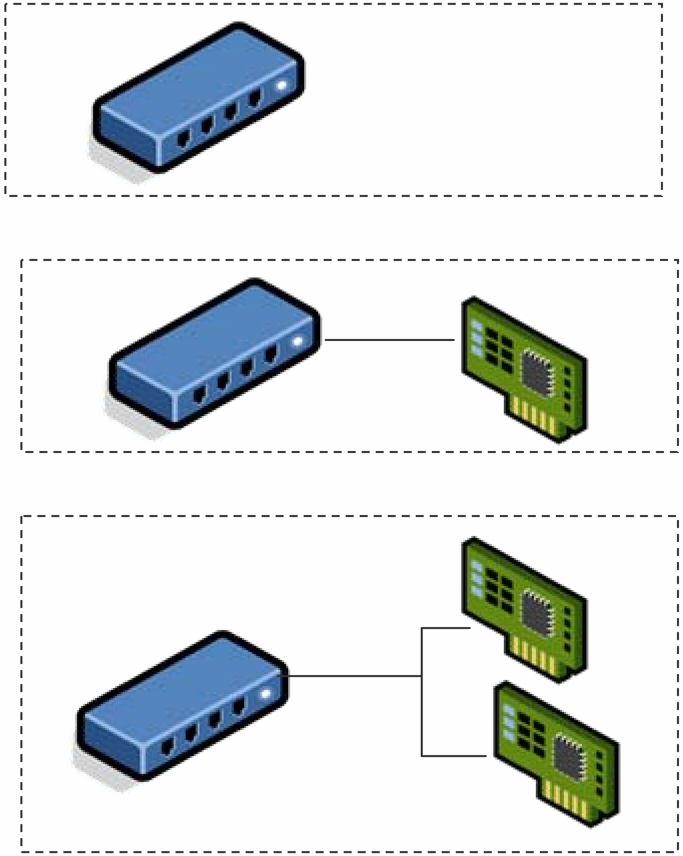
New functionalities could be plugged

All network traffic has to go through some virtual switch

VMKernel uses modified Linux drivers

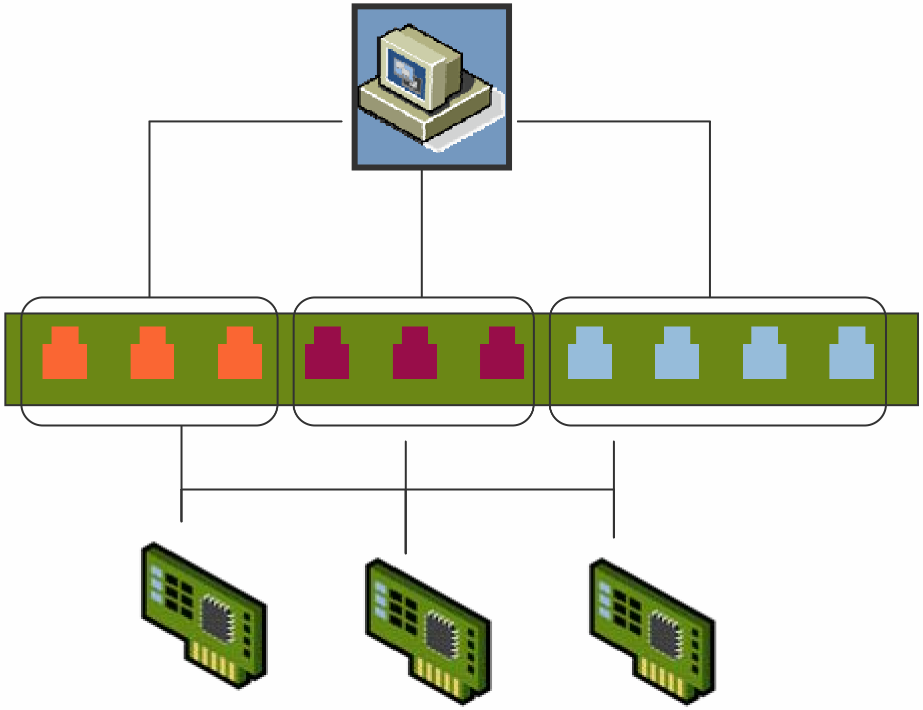
All the Physical NICs are managed by VMkernel

Virtual Switch



- Operates at Layer 2, no layer 3 functionalities.
- Can have zero or more uplinks (Physical NICs)
- Cannot share (uplinks) physical NICs with other virtual switches
- To use a virtual switch there should be at least one portgroup defined

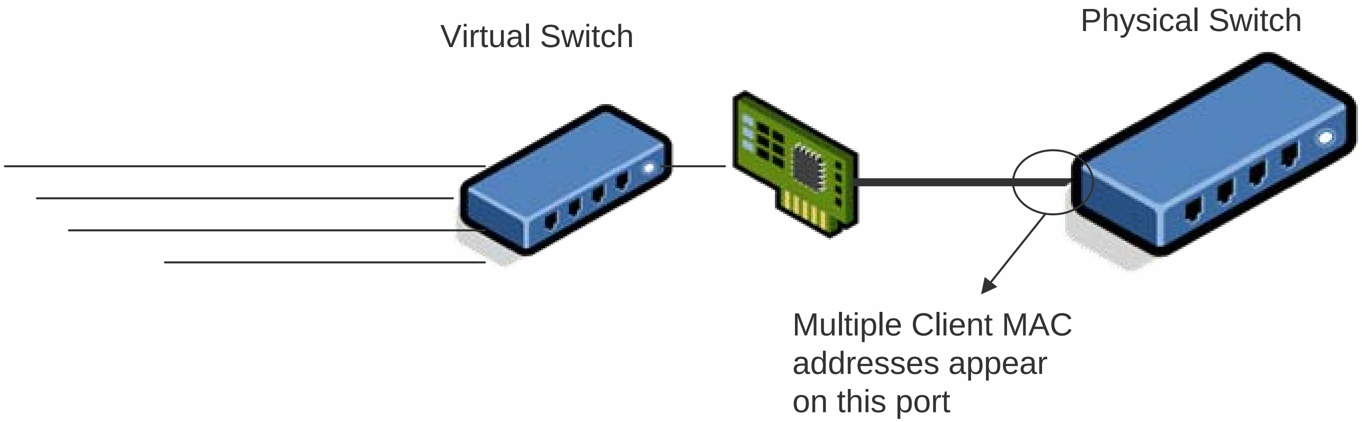
Portgroups



- Portgroups do not segment broadcast domain
  - VLANs segment broadcast domains
- Clients inherit the properties of the portgroups (in ESX 2.x properties are specified to the virtual NIC)
- Portgroup policies Overrides virtual switch policies.
- Can use subset of NICs available to the virtual switch
- Can share NICs with other portgroups on the same virtual switch
- Implication: Same set of Physical NICs can be used with different policy settings. For ex. VLAN, NIC teaming etc.

Virtual Switch: External View

- Virtual Switch behaves like a dumb switch
- Does not speak
  - STP - Don’t have to, No Loops possible
- Does not speak DTP, VTP, ISL etc
- Does not speak LACP
  - Physical Switch ports have to be aggregated in Manual mode
- Optional CDP support planned for the future version

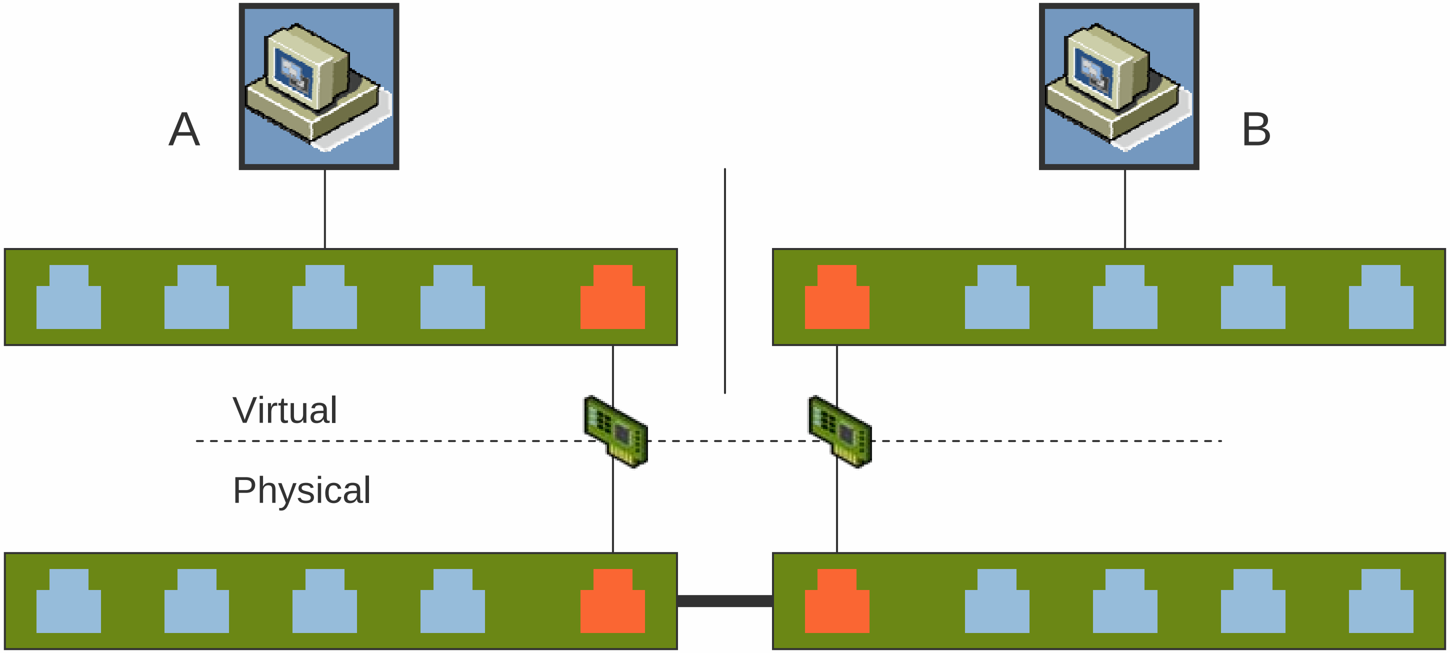


Virtual Switch: Internal View

- MAC address learning
  - Unlike physical switches Virtual Switch does not learn MAC addresses from the traffic flow
  - Virtual NICs notify MAC address when they register
  - Every other unicast MAC address belong to uplink port
- Link negotiation
  - Virtual NIC does not negotiates speed/duplex with the virtual switch
  - Virtual NICs do not reflect the speed/duplex state of the Uplink (physical NIC)
  - Guest reports link down status when the virtual ethernet device is disconnected in the UI

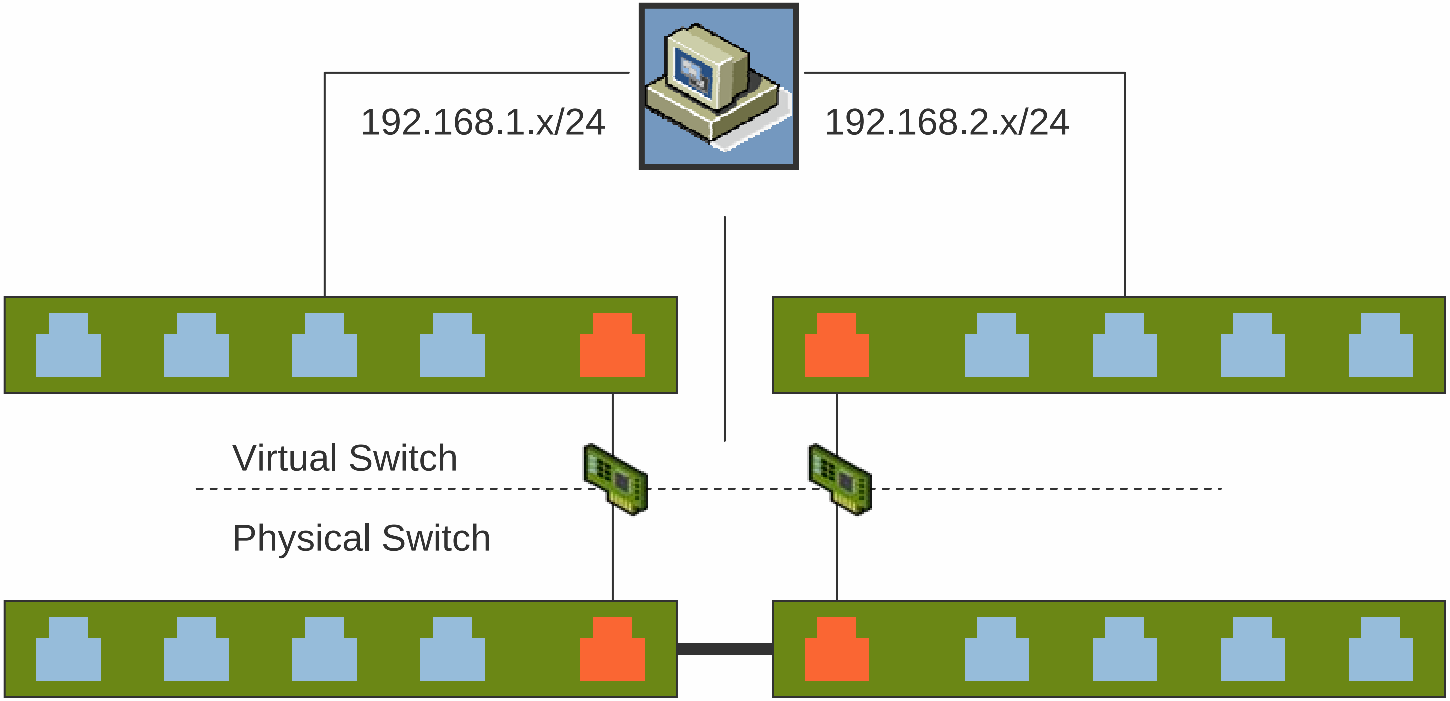
Virtual Switch Boundaries

- Virtual switches are isolated. i.e. Trunking is not possible between virtual switches. Only uplinks connect virtual switches.
- Communication from VM A to VM B can happen only through external network



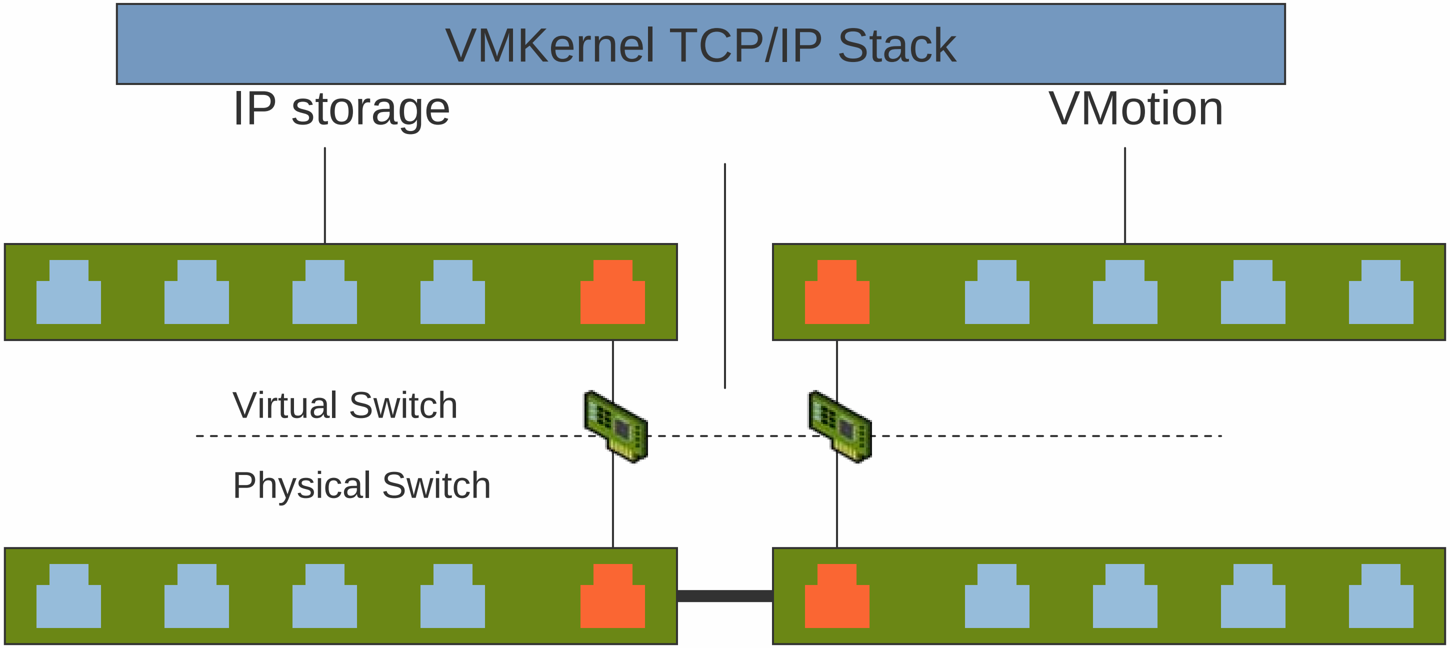
Virtual Switch Boundaries

- Virtual Machines can interconnect Virtual Switch
- Virtual NICs need to be placed in different subnet to use both virtual switches
- Layer 2 Loops possible if the VM acts like a bridge

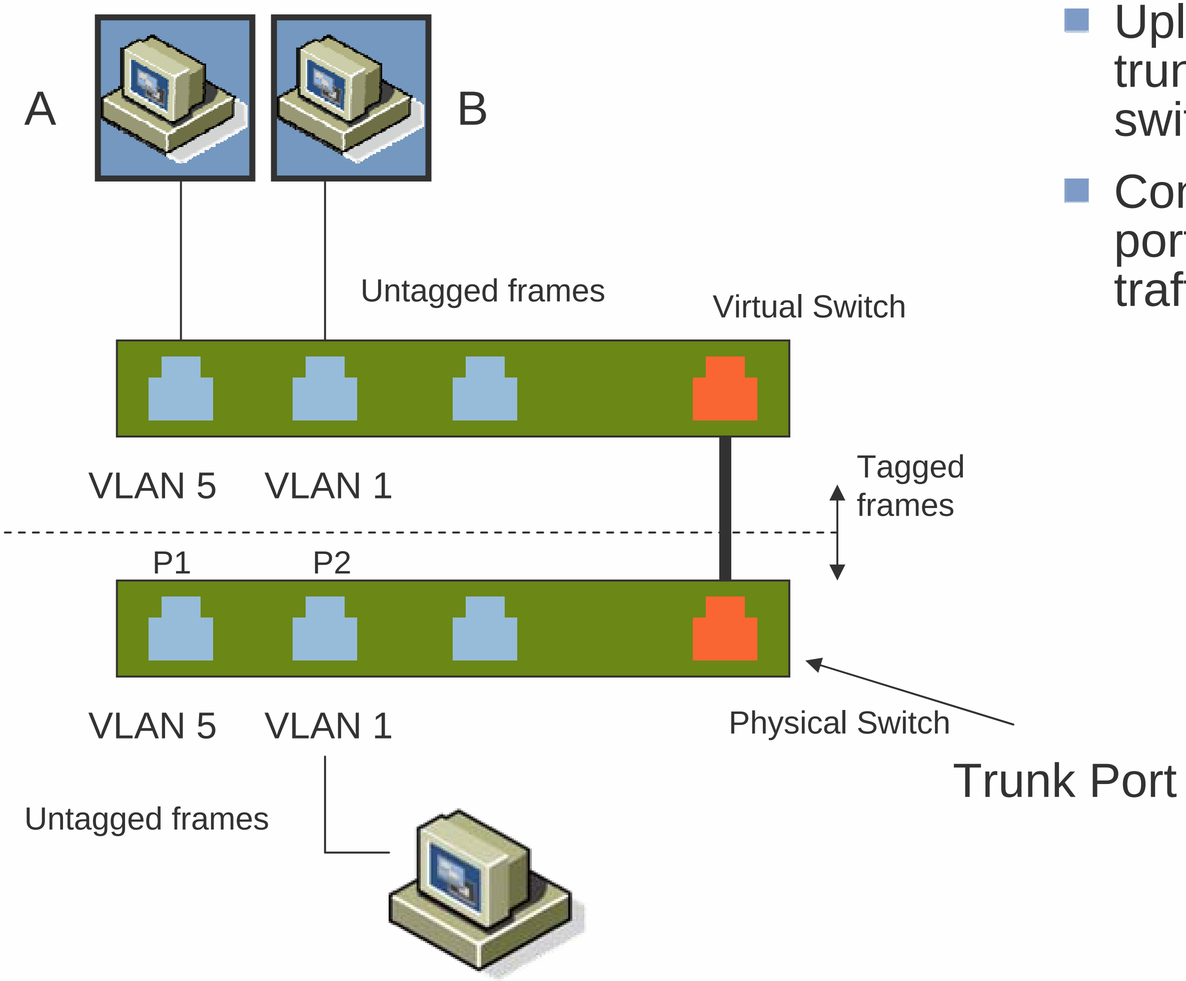


Virtual Switch Boundaries

- VMKernel TCP/IP Stack routing table determines packet flow
- Put IP Storage and VMotion on separate subnets for isolation
- Traffic will go through the same virtual switch if they are in the same subnet

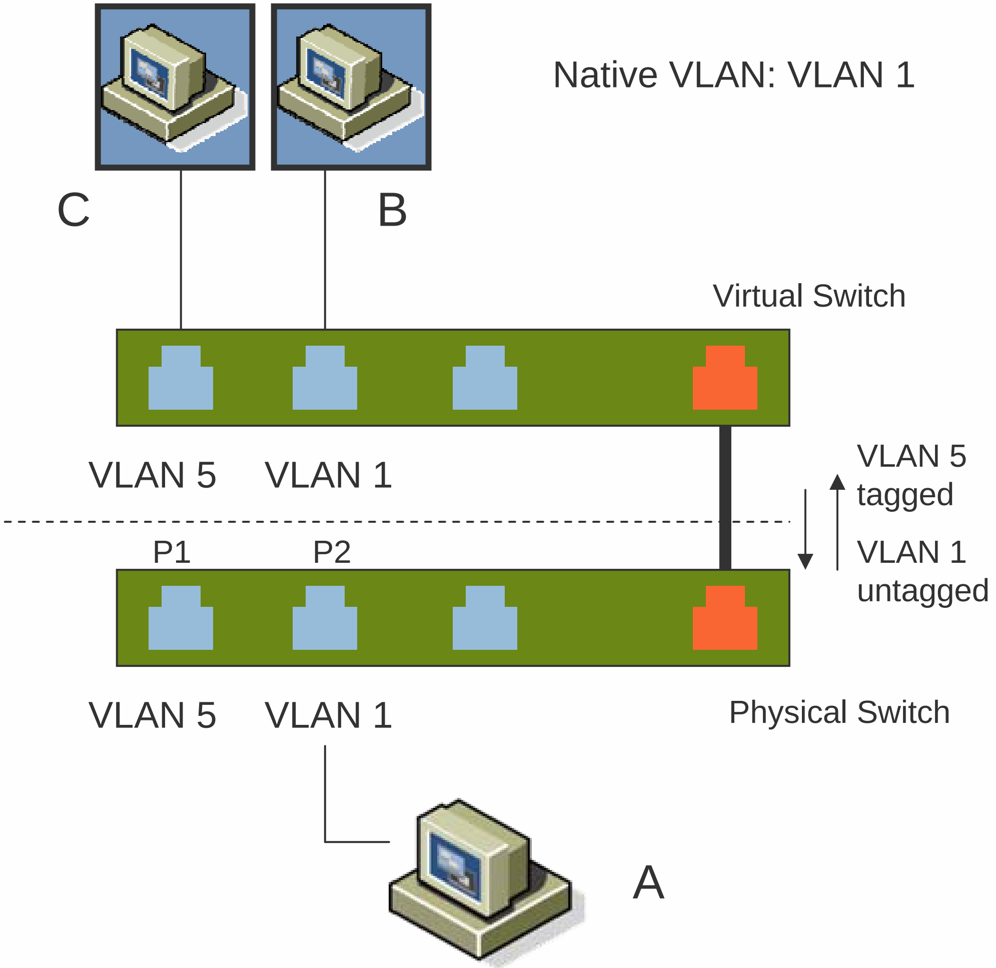


VLAN: Why Trunk ?



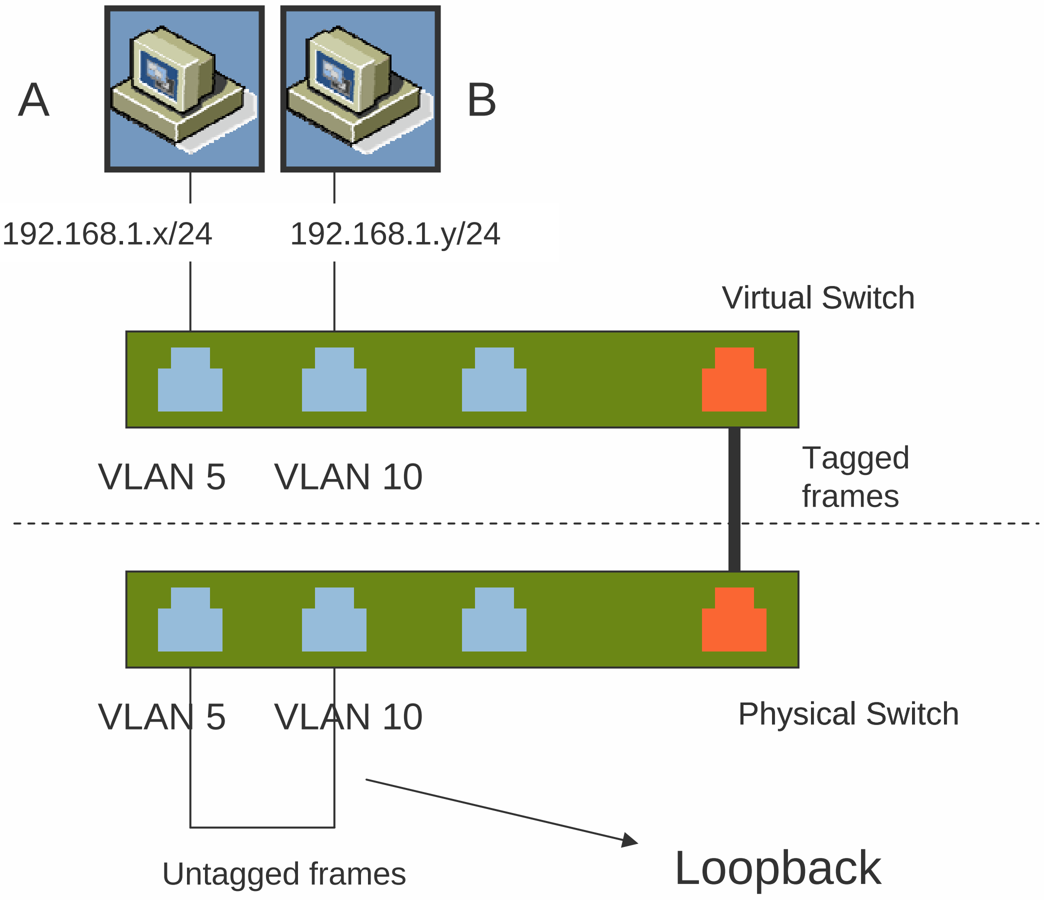
- Uplink in a virtual switch is a trunk link to the physical switch
- Configure the physical switch port as a trunk port to allow traffic with tagged frames

Native VLAN



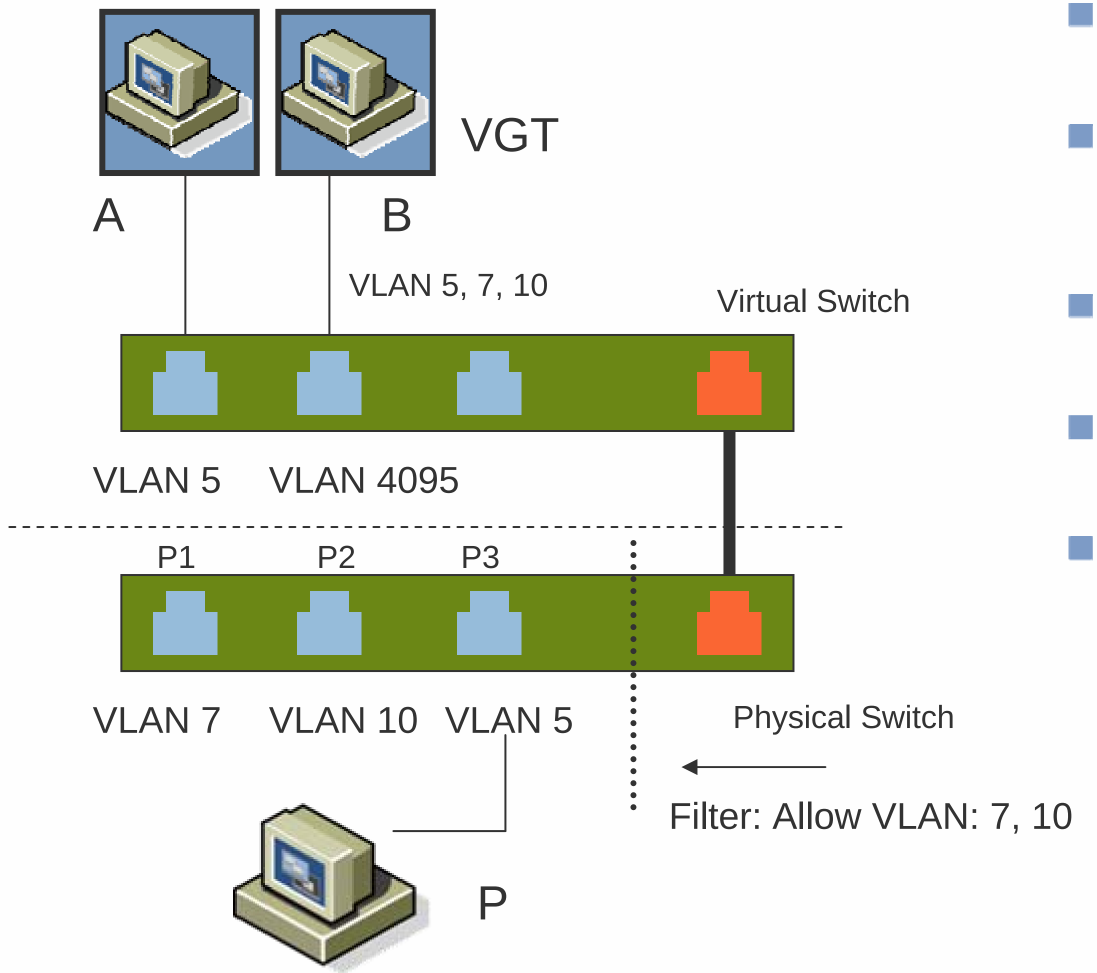
- Physical Switch does not tag frames on the Native VLAN
- Virtual Switch does not have the notion of Native VLAN
- Communication A – B fails: Virtual switch forwards only tagged frames to B
- Communication B – A may or may not fail: Physical switch may or may not accept tagged frames on native VLAN
- Workaround: Put VM B on an portgroup with no VLAN tagging or enforce tagging on switch port P2

Virtual Switch VLAN Behavior Example



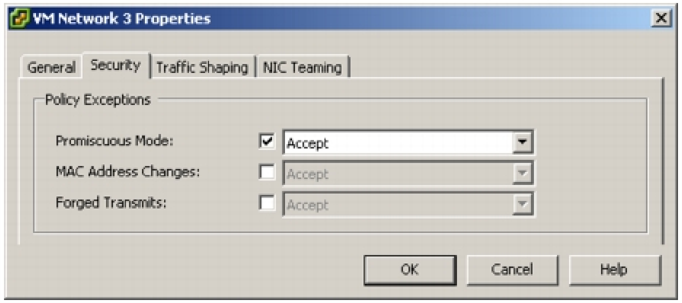
- Loopback cable interconnects VLAN 5 and VLAN 10 into the same broadcast domain
- VM A and VM B can talk to each other
- In ESX 2.x the response packets from VM B will not reach VM A. Path optimization prevents this communication
- ESX 3.x avoids this problem

VGT: Security Implications



- VLAN id 4095 enables VGT mode in ESX 3.x
- In VGT mode guest can send/receive any VLAN tagged frame (0-4094).
- Virtual switch does not filters VLAN
- Filtering could be done in the physical switch port
- However VM B could still talk to VM A

Layer 2 Security



Policy Exceptions

Promiscuous Mode: ☑ Accept

MAC Address Changes: □ Accept

Forged Transmits: □ Accept

- ESX Layer 2 security options give a level of control beyond what is usually possible in physical environments
- **Promiscuous Mode: Deny**
  - Virtual NIC will appear to go into promiscuous mode, but it won’t receive any additional frames
- **Forged transmits: Deny**
  - drop any frames which the guest sends with a source MAC different from the one currently registered
- **MAC address changes: Deny**
  - if the guest attempts to change the MAC address to something other than what’s configured for the virtual HW, stop giving it frames

Layer 2 Security

- Why “Deny MAC Address Changes” ?
  - Guest can change its MAC address to send spoofed frames
  - Guest can change its MAC address to listen to other traffic when promiscuous mode is denied.
- To restrict the VM to use only its MAC address enforce “Deny MAC Address Changes” and “Deny Disallow Forged transmits”
- Deny all three options for complete layer 2 security

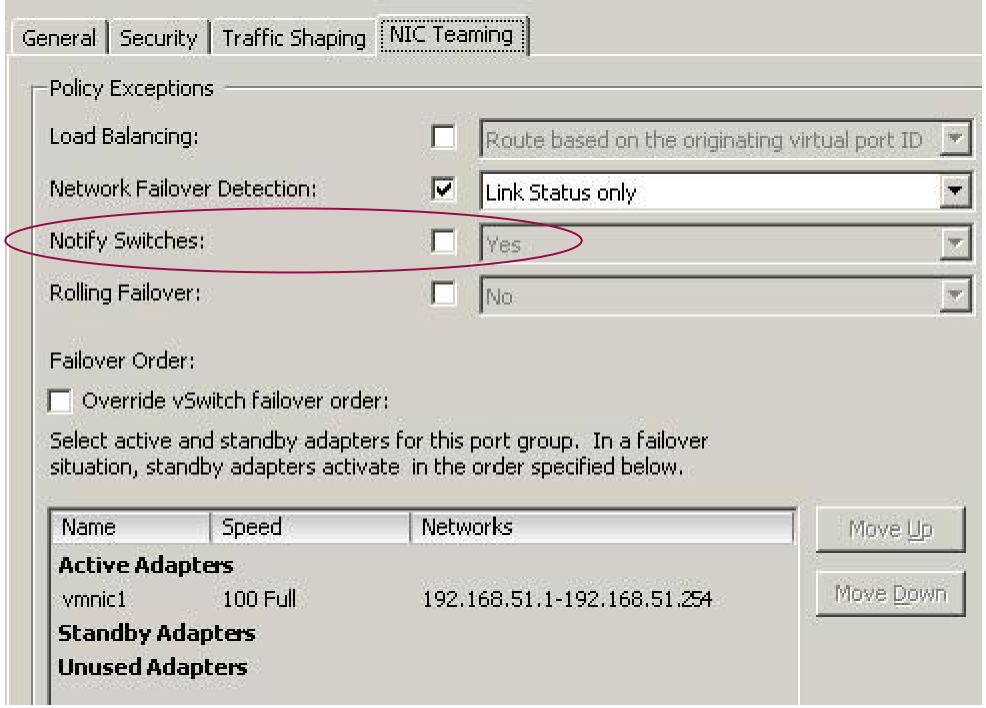
Layer 2 Security: Interactions

- Microsoft Network Load Balancing
  - Deny Forged transmits will break Microsoft Network Load Balancing operating in Unicast mode
  - In Unicast mode Cluster nodes use fake MAC address for outgoing traffic to prevent switches from learning true MAC address. This technique allows the incoming traffic for the cluster IP to be sent to all the ports of the physical switch.

Layer 2 Security: Interactions

- Windows IP address conflicts
  - Deny Forged transmits will cause machines on the network to point to the offending machine instead of defending machine in the case of IP address conflict
  - Windows Sends gratuitous ARP (ARP request for its own IP) to detect duplicate IP address. If a host responds back, then duplicate IP
  - In the event a host responds back (duplicate IP found), windows sends forged ARP request containing the MAC address of the defending machine. This updates the ARP table of the machines in the network with the IP address of the defending machine.

Switch Notification



Policy Exceptions

Load Balancing: □ Route based on the originating virtual port ID

Network Failover Detection: ☑ Link Status only

Notify Switches: □ Yes

Rolling Failover: □ No

Failover Order:

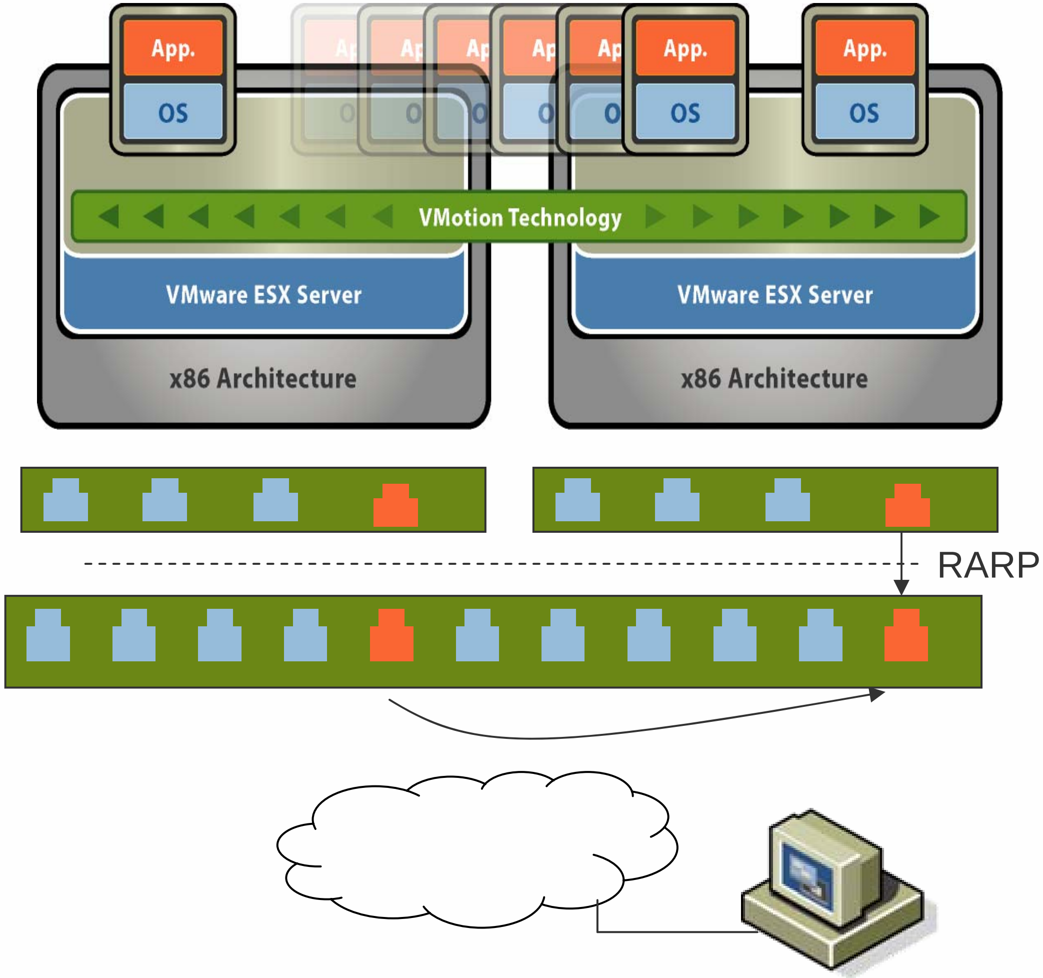
□ Override vSwitch failover order:

Select active and standby adapters for this port group. In a failover situation, standby adapters activate in the order specified below.

Name	Speed	Networks
Active Adapters		
vmnic1	100 Full	192.168.51.1-192.168.51.254
Standby Adapters		
Unused Adapters		

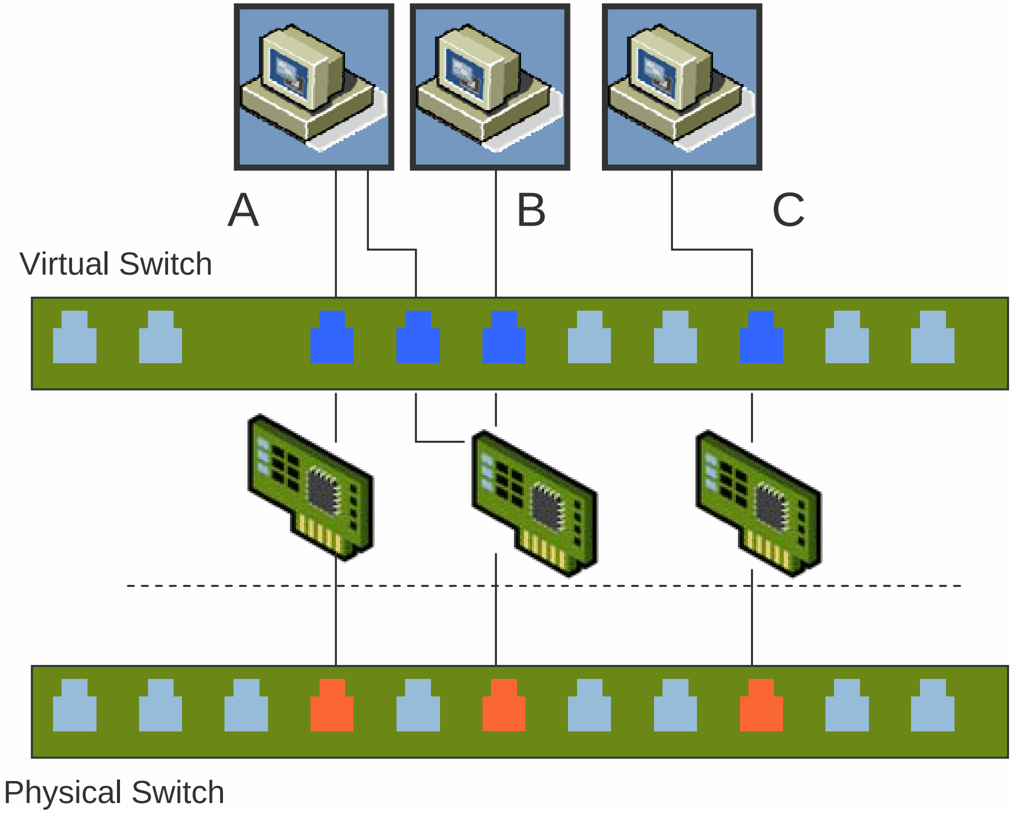
- Client MAC address is notified to the physical switch using RARP frame
- When ?
  - Whenever Client register itself with virtual switch
  - VM power on, Vmotion, Changing MAC, Teaming status change etc
- Why ?
  - Allows the physical switch to learn MAC immediately
- Why RARP ?:
  - L2 broadcast reaches every switch
  - Doesn’t disrupts ARP cache
  - L3 information not needed to send RARP

Switch Notification: VMotion



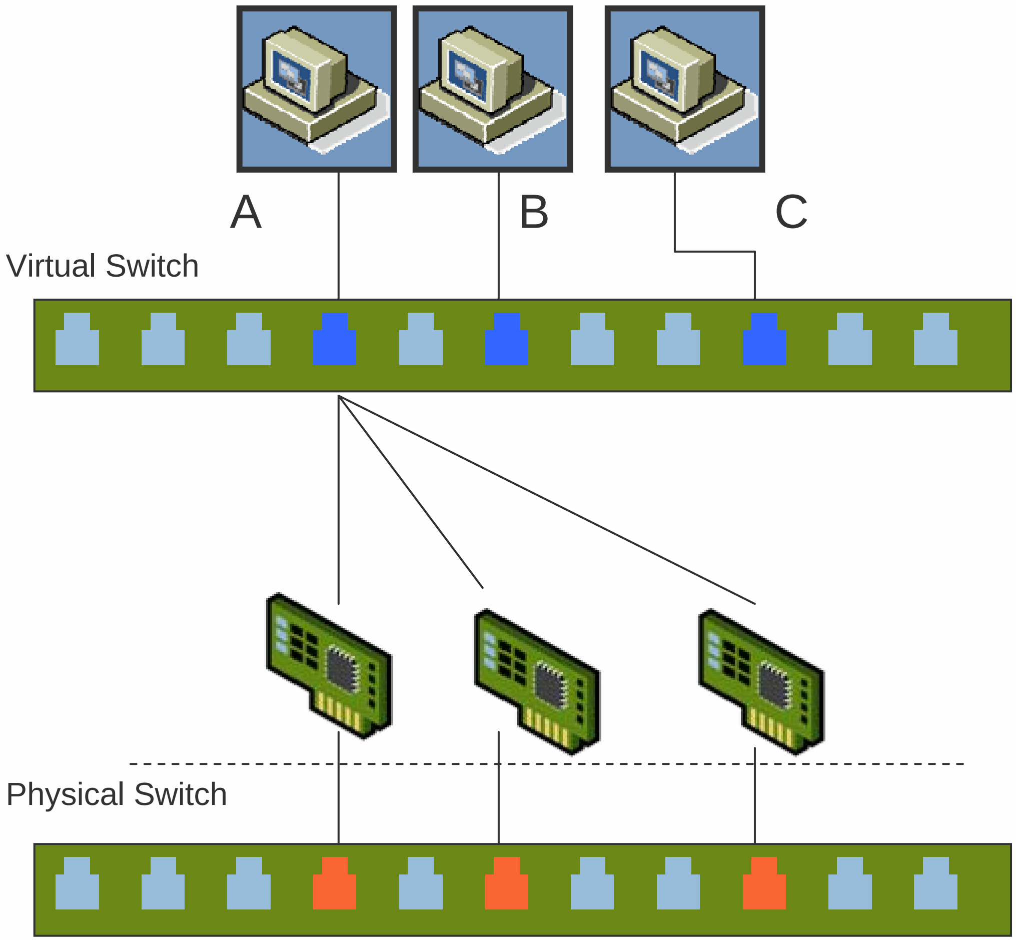
- VMotion moves the VM from one switch port to another
- Virtual Switches on source and destination should have identical L2 security policy (VC Checks this)
- Source and destination port should be in the same broadcast domain (implies same VLAN).
- Virtual NIC is unplugged on the source and plugged back at the destination host – triggers switch notification

Load Balancing: Source MAC/Originating Port ID



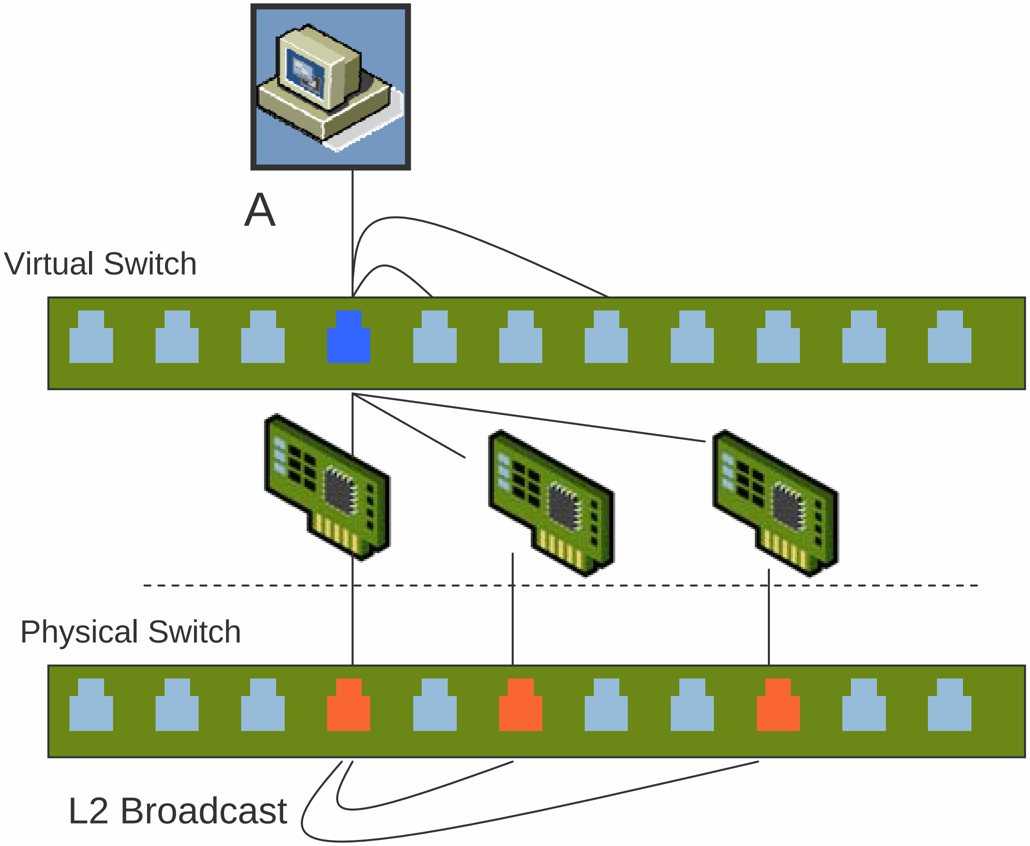
- Outbound NIC is chosen based on source MAC or originating port id
- Client traffic is consistently sent to the same physical NIC until there is a failover
- Replies are received on the same NIC as the physical switch learns the MAC/ switch port association
- Better scaling if: no of vNICs > no of pNICs
- VM cannot use more than one Physical NIC unless it has two or more virtual NICs

Load Balancing: IP Hash (out-IP)



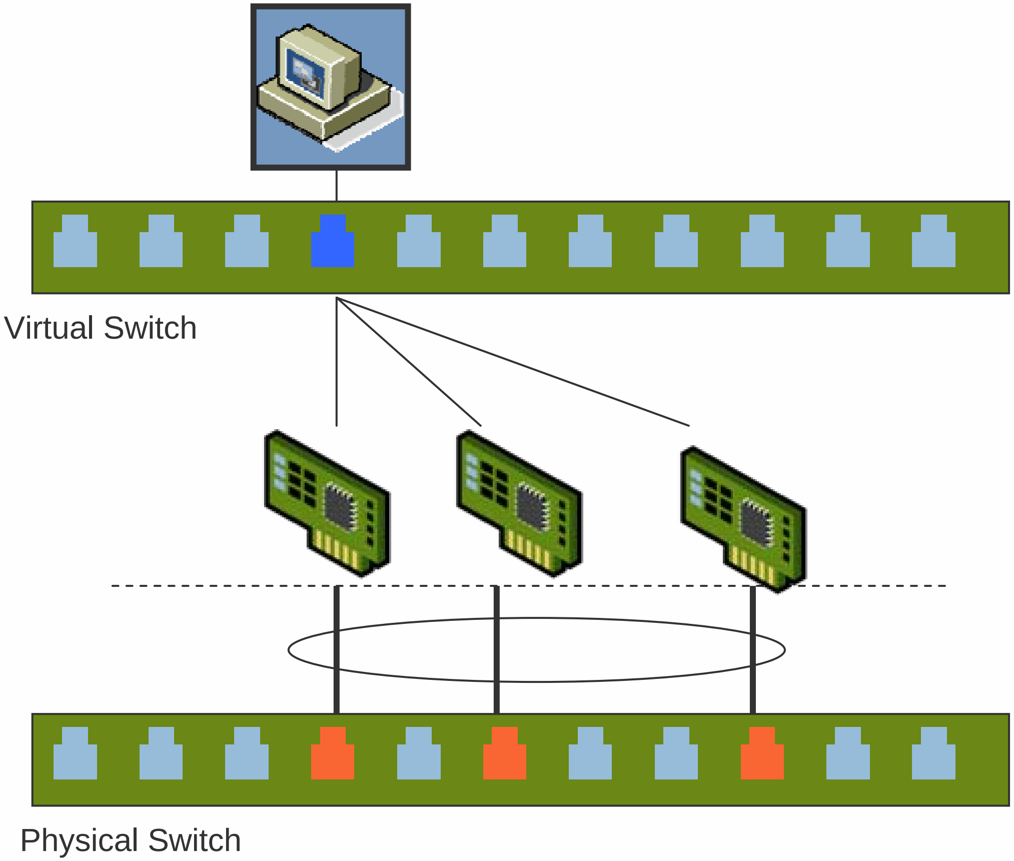
- Outbound NIC is chosen based on “Source-destination L3 address pair”
- Scalability is dependent on the no of TCP/IP sessions to unique destinations. No benefit for bulk transfer between hosts
- Physical switch will see the client MAC on multiple ports
  - Can disrupt MAC address learning on the physical switch
  - Inbound traffic is unpredictable.

NIC Teaming: Packet Reflections



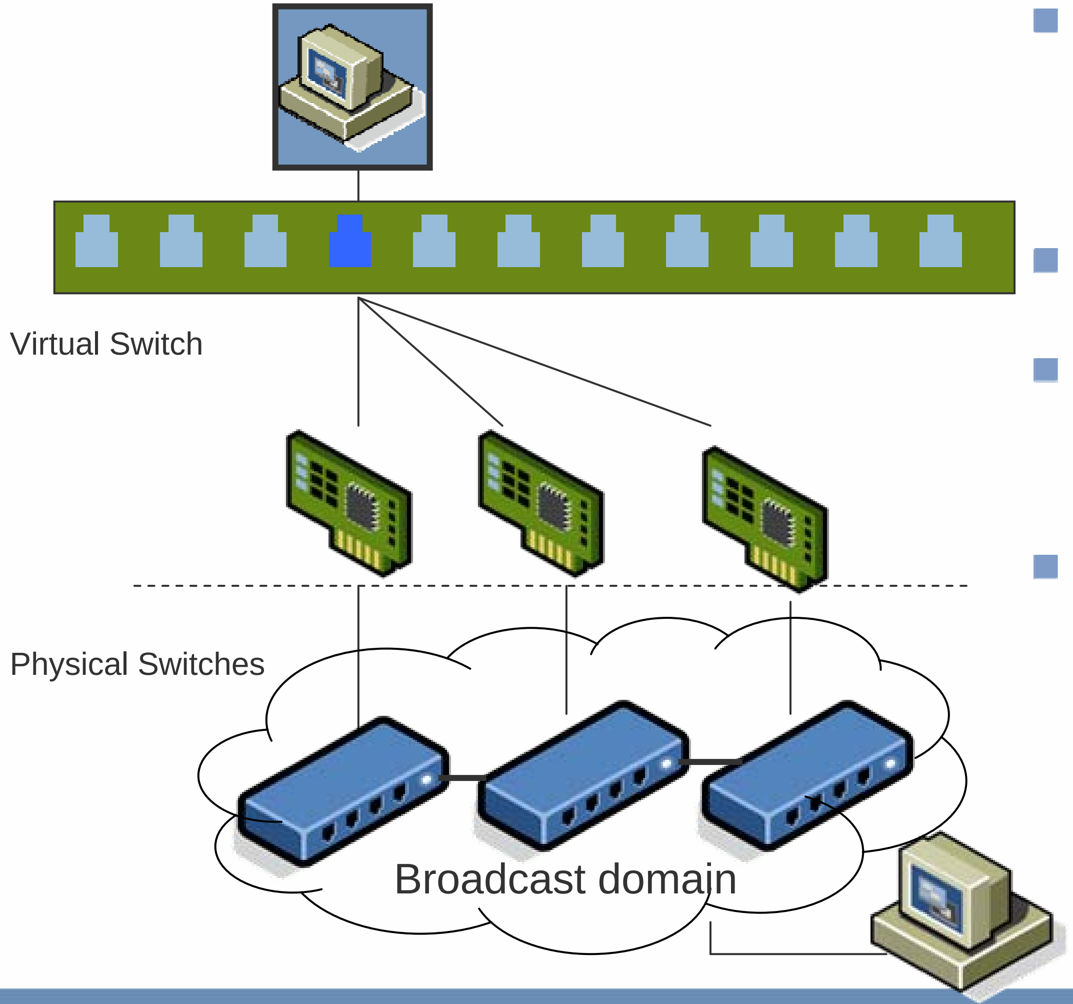
- Broadcast / Multicast packets return to the VM through other NICs in the team
- Most Guest OS’es ignore duplicate packets
- Avoid NIC Teaming if the VM relies on frequent broadcast / multicast packets (for ex. Microsoft Network Load Balancing)
- ESX 3.x filters packet reflections
  - Frames received on wrong link is
    - Discarded in source mac/originating port id mode
    - Allowed in out-ip mode

Link Aggregation



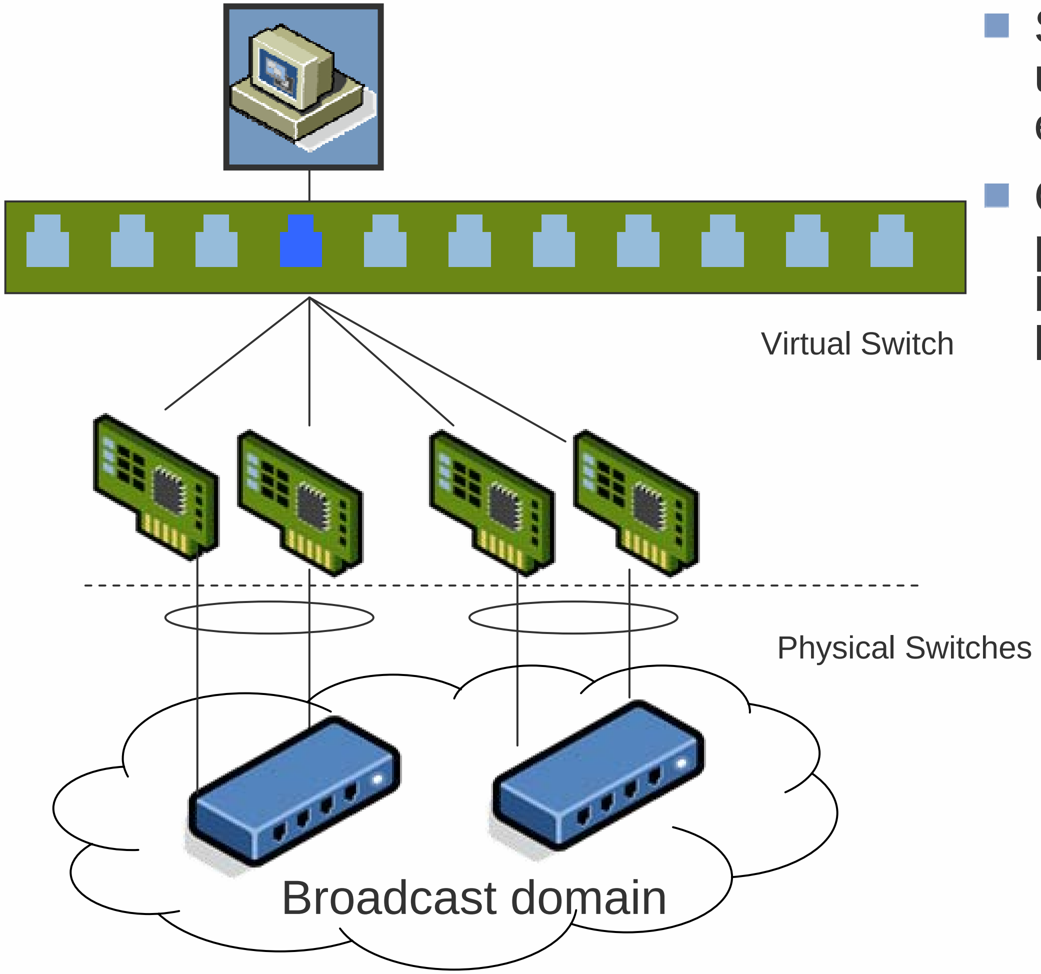
- Allows load balancing of incoming traffic.
- Packet reflections are prevented - Aggregated ports do not re-send broadcast / multicast traffic
- Works well with out-ip since aggregated ports share a single entry in the MAC lookup table
- Throughput aggregation benefits are less relevant with the advent of gigabit and 10G Links
- Traffic flow is unpredictable
- Source mac/Source port id mode load is incompatible with Link aggregation in ESX 3.x

NIC Teaming: Multi Switch Configuration



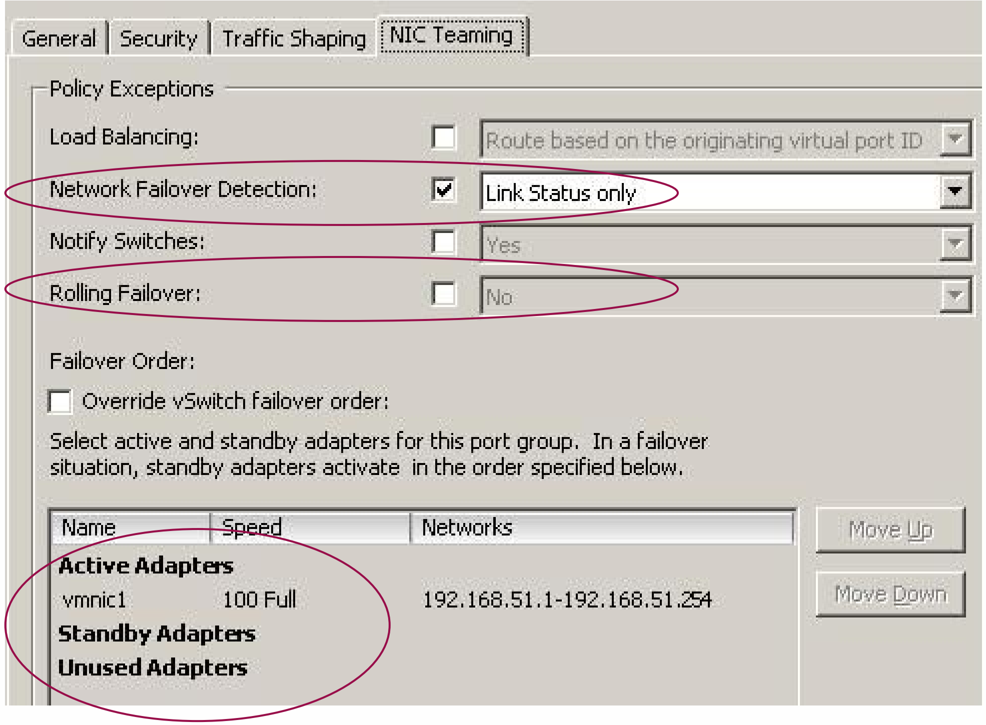
- Physical NICs can be connected to different switches as long as they remain in the same broadcast domain
- Physical switches should be trunked or ISL'ed
- Expect problems if the port on each physical switch is configured with different VLAN/trunking options
- IP-hash (out-ip) mode is not recommended
  - Client MAC address can appear on all the physical switches
  - Client MAC address can appear on trunk ports

NIC Teaming: Multi Switch With Link Aggregation



- Same scenario as before, but uses link aggregation on each switch
- Currently ports from different physical switches could not be aggregated into a single link

NIC Teaming: Failover Scenarios



Policy Exceptions

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Network Failover Detection: ☑ Link Status only

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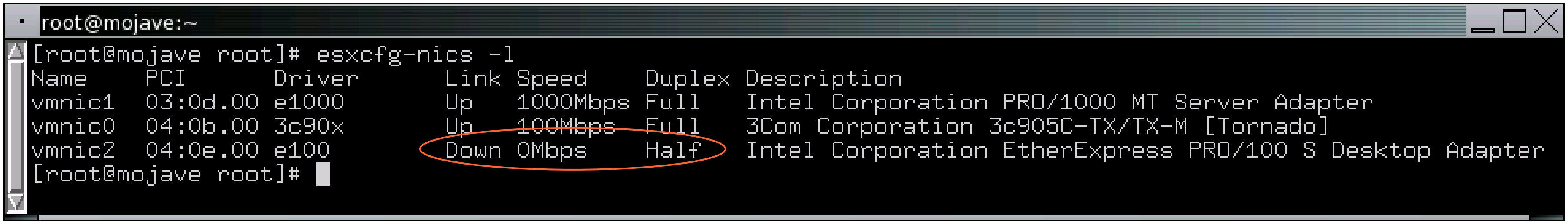
Standby Adapters		
Unused Adapters		

- Failover detection
  - Ethernet Link failure
  - Switch failure (beaconing)
- Fail-back
  - Rolling failover : No - Fail back is on
- Failover order
  - Order of Standby Adapters
- Unused Adapters – NICs excluded from teaming
- Changing the Order of Active Adapters switches the traffic flow through the NICs

NIC Teaming: Failover Implications

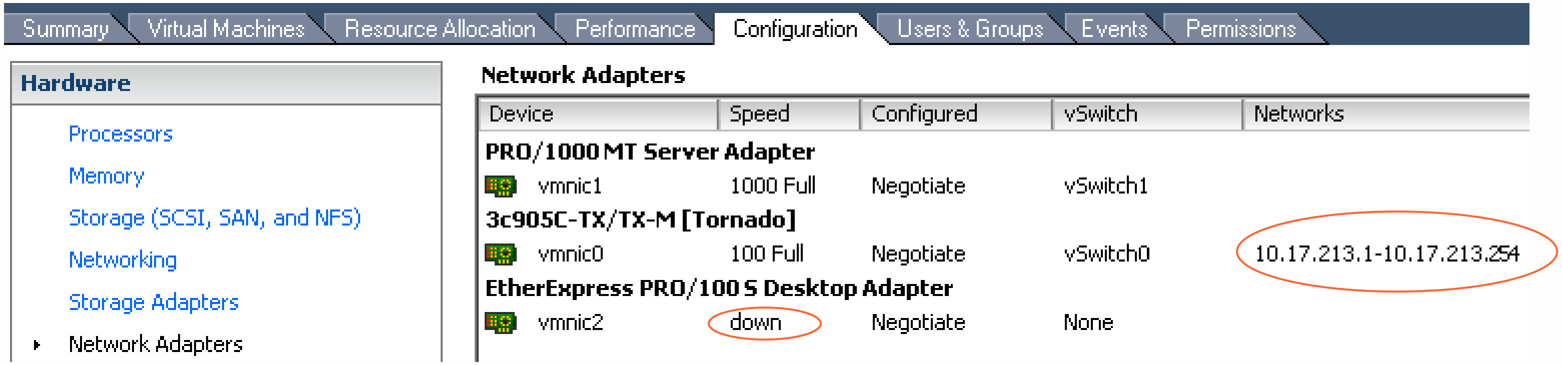
- Fail-back is on by default. If link is flaky physical switch will notice client MAC address on multiple ports frequently
- Virtual switch uses the link as soon as it is up. Physical switch port may not accept traffic immediately when the link comes online
- To minimize delays disable
  - STP (use portfast mode instead) – 30 secs
  - Etherchannel negotiation, like PAgP (use manual mode) – 15 secs
  - Trunking negotiation – 4 secs
  - Link autonegotiation (Speed/duplex settings) – 2 secs

Diagnostics: Link state



root@mojave:~

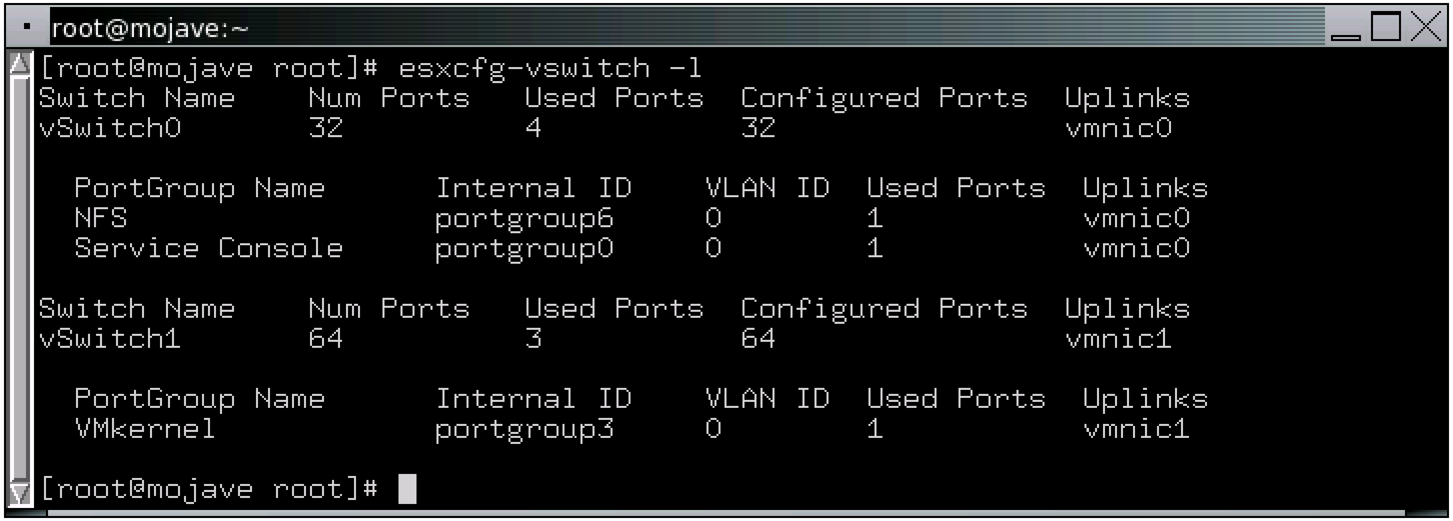
```
[root@mojave root]# esxcfg-nics -l
Name     PCI        Driver      Link Speed     Duplex Description
vmnic1   03:0d.00 e1000       Up   1000Mbps Full   Intel Corporation PRO/1000 MT Server Adapter
vmnic0   04:0b.00 3c90x       Up   100Mbps  Full   3Com Corporation 3c905C-TX/TX-M [Tornado]
vmnic2   04:0e.00 e100        Down 0Mbps    Half   Intel Corporation EtherExpress PRO/100 S Desktop Adapter
[root@mojave root]#
```



Network Adapters

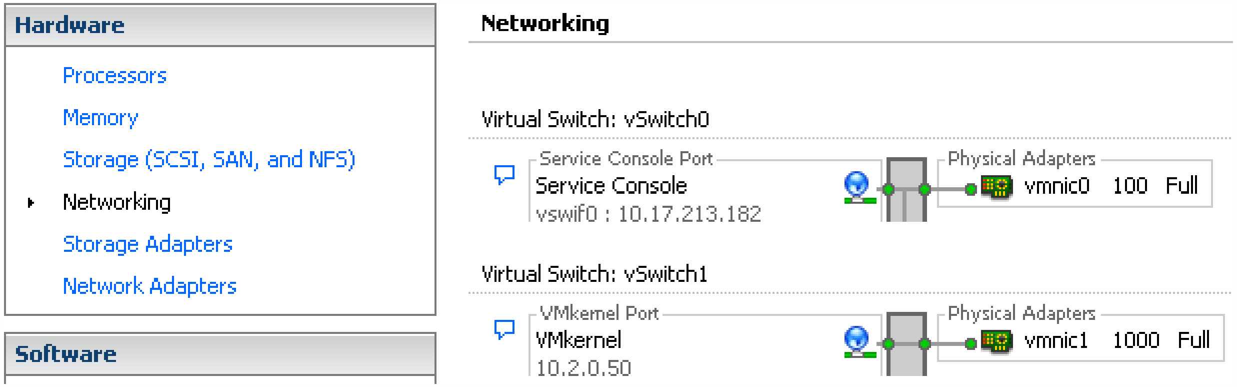
Device	Speed	Configured	vSwitch	Networks
PRO/1000 MT Server Adapter				
vmnic1	1000 Full	Negotiate	vSwitch1	
3c905C-TX/TX-M [Tornado]				
vmnic0	100 Full	Negotiate	vSwitch0	10.17.213.1-10.17.213.254
EtherExpress PRO/100 S Desktop Adapter				
vmnic2	down	Negotiate	None	

Diagnostics: Portgroup settings



root@mojave:~

```
[root@mojave root]# esxcfg-vswitch -l
Switch Name    Num Ports   Used Ports  Configured Ports  Uplinks
vSwitch0       32          4           32                vmnic0

  PortGroup Name        Internal ID    VLAN ID  Used Ports  Uplinks
  NFS                   portgroup6     0        1           vmnic0
  Service Console       portgroup0     0        1           vmnic0

Switch Name    Num Ports   Used Ports  Configured Ports  Uplinks
vSwitch1       64          3           64                vmnic1

  PortGroup Name        Internal ID    VLAN ID  Used Ports  Uplinks
  VMkernel              portgroup3     0        1           vmnic1

[root@mojave root]# █
```



Hardware

- Processors
- Memory
- Storage (SCSI, SAN, and NFS)
- ▸ Networking
- Storage Adapters
- Network Adapters

Software

Networking

Virtual Switch: vSwitch0

Service Console Port
Service Console
vswif0 : 10.17.213.182

Physical Adapters
vmnic0 100 Full

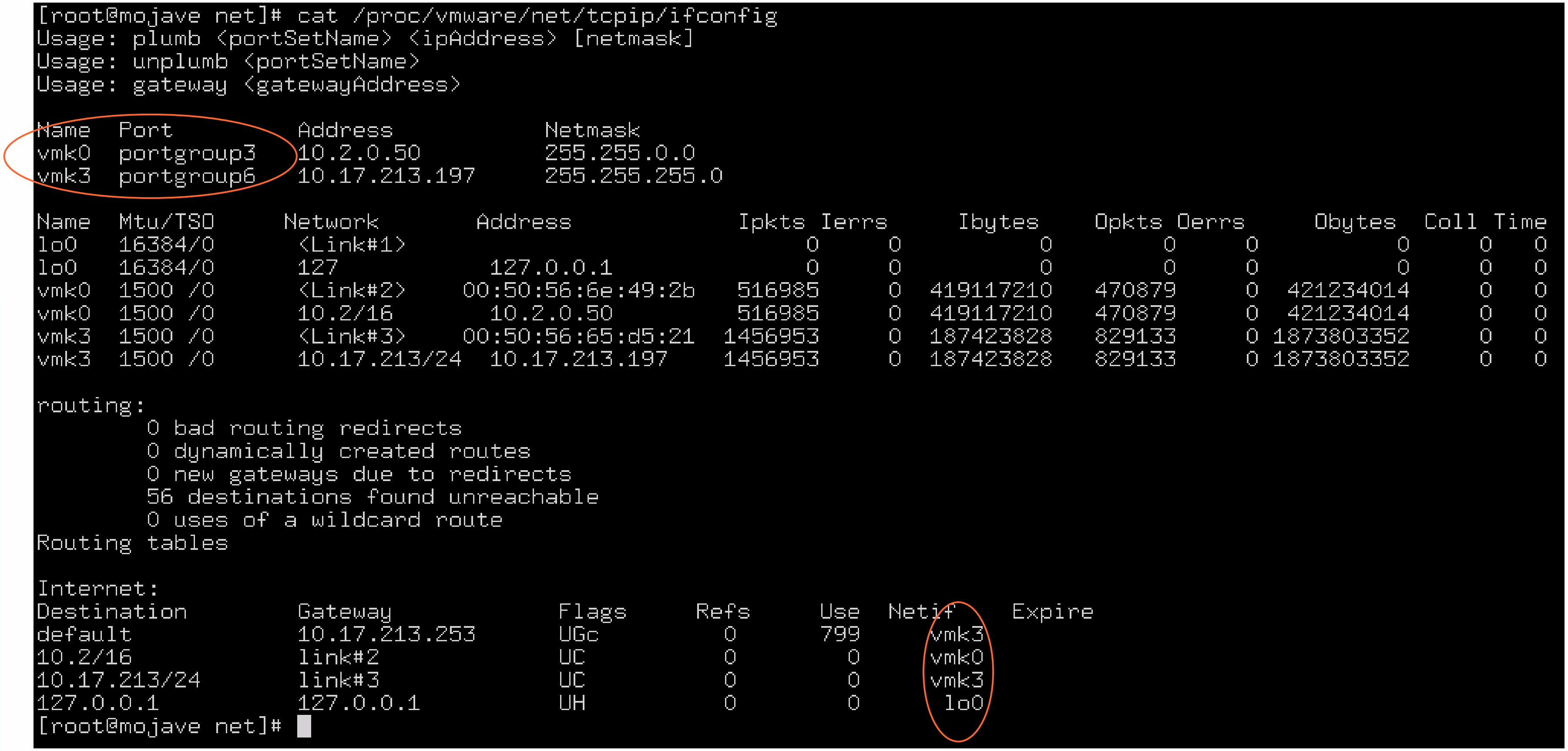
Virtual Switch: vSwitch1

VMkernel Port
VMkernel
10.2.0.50

Physical Adapters
vmnic1 1000 Full

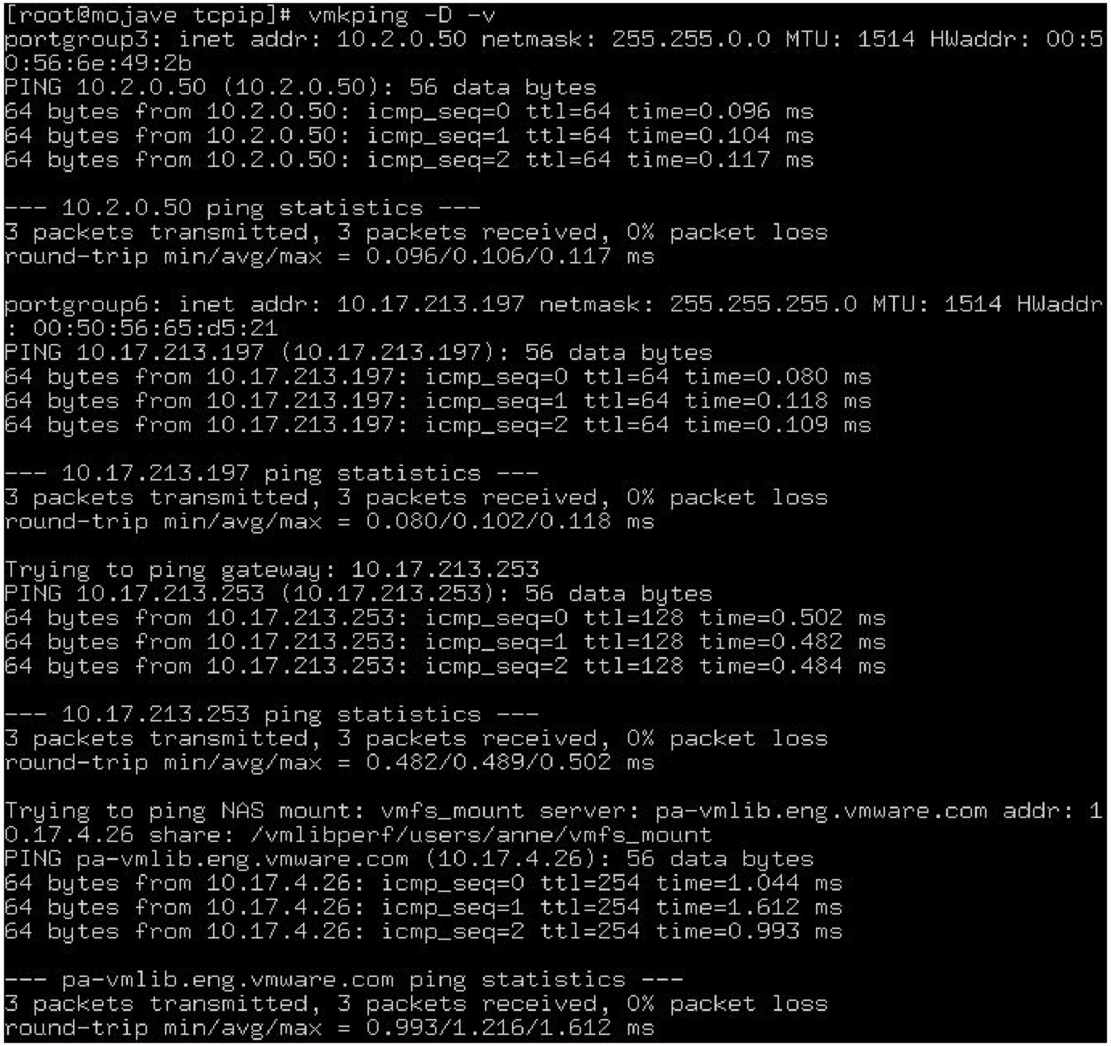
Diagnostics: VMKernel TCP/IP Stats

- cat /proc/vmware/net/tcpip/ifconfig



```
[root@mojave net]# cat /proc/vmware/net/tcpip/ifconfig
Usage: plumb <portSetName> <ipAddress> [netmask]
Usage: unplumb <portSetName>
Usage: gateway <gatewayAddress>

Name  Port         Address           Netmask
vmk0  portgroup3   10.2.0.50         255.255.0.0
vmk3  portgroup6   10.17.213.197     255.255.255.0

Name  Mtu/TSO     Network       Address            Ipkts Ierrs     Ibytes    Opkts Oerrs     Obytes  Coll Time
lo0   16384/0      <Link#1>                             0     0          0        0     0          0     0   0
lo0   16384/0      127           127.0.0.1              0     0          0        0     0          0     0   0
vmk0  1500 /0      <Link#2>    00:50:56:6e:49:2b   516985     0  419117210   470879     0  421234014     0   0
vmk0  1500 /0      10.2/16       10.2.0.50         516985     0  419117210   470879     0  421234014     0   0
vmk3  1500 /0      <Link#3>    00:50:56:65:d5:21  1456953     0  187423828   829133     0 1873803352     0   0
vmk3  1500 /0      10.17.213/24  10.17.213.197    1456953     0  187423828   829133     0 1873803352     0   0

routing:
        0 bad routing redirects
        0 dynamically created routes
        0 new gateways due to redirects
        56 destinations found unreachable
        0 uses of a wildcard route
Routing tables

Internet:
Destination        Gateway            Flags     Refs     Use  Netif    Expire
default            10.17.213.253      UGc         0      799     vmk3
10.2/16            link#2             UC          0        0     vmk0
10.17.213/24       link#3             UC          0        0     vmk3
127.0.0.1          127.0.0.1          UH          0        0      lo0
[root@mojave net]#
```

Diagnostics: vmkping



```
[root@mojave tcpip]# vmkping -D -v
portgroup3: inet addr: 10.2.0.50 netmask: 255.255.0.0 MTU: 1514 HWaddr: 00:5
0:56:6e:49:2b
PING 10.2.0.50 (10.2.0.50): 56 data bytes
64 bytes from 10.2.0.50: icmp_seq=0 ttl=64 time=0.096 ms
64 bytes from 10.2.0.50: icmp_seq=1 ttl=64 time=0.104 ms
64 bytes from 10.2.0.50: icmp_seq=2 ttl=64 time=0.117 ms

--- 10.2.0.50 ping statistics ---
3 packets transmitted, 3 packets received, 0% packet loss
round-trip min/avg/max = 0.096/0.106/0.117 ms

portgroup6: inet addr: 10.17.213.197 netmask: 255.255.255.0 MTU: 1514 HWaddr
: 00:50:56:65:d5:21
PING 10.17.213.197 (10.17.213.197): 56 data bytes
64 bytes from 10.17.213.197: icmp_seq=0 ttl=64 time=0.080 ms
64 bytes from 10.17.213.197: icmp_seq=1 ttl=64 time=0.118 ms
64 bytes from 10.17.213.197: icmp_seq=2 ttl=64 time=0.109 ms

--- 10.17.213.197 ping statistics ---
3 packets transmitted, 3 packets received, 0% packet loss
round-trip min/avg/max = 0.080/0.102/0.118 ms

Trying to ping gateway: 10.17.213.253
PING 10.17.213.253 (10.17.213.253): 56 data bytes
64 bytes from 10.17.213.253: icmp_seq=0 ttl=128 time=0.502 ms
64 bytes from 10.17.213.253: icmp_seq=1 ttl=128 time=0.482 ms
64 bytes from 10.17.213.253: icmp_seq=2 ttl=128 time=0.484 ms

--- 10.17.213.253 ping statistics ---
3 packets transmitted, 3 packets received, 0% packet loss
round-trip min/avg/max = 0.482/0.489/0.502 ms

Trying to ping NAS mount: vmfs_mount server: pa-vmlib.eng.vmware.com addr: 1
0.17.4.26 share: /vmlibperf/users/anne/vmfs_mount
PING pa-vmlib.eng.vmware.com (10.17.4.26): 56 data bytes
64 bytes from 10.17.4.26: icmp_seq=0 ttl=254 time=1.044 ms
64 bytes from 10.17.4.26: icmp_seq=1 ttl=254 time=1.612 ms
64 bytes from 10.17.4.26: icmp_seq=2 ttl=254 time=0.993 ms

--- pa-vmlib.eng.vmware.com ping statistics ---
3 packets transmitted, 3 packets received, 0% packet loss
round-trip min/avg/max = 0.993/1.216/1.612 ms
```

- ping command uses service console TCP/IP Stack
- vmkping uses VMKernel TCP/IP stack

Diagnostics: Collecting Network Traces

- Run tcpdump/ethereal/netmon inside the guest or in the service console
- Traffic visibility depends on the portgroup policy settings
  - Portgroup with VLAN id 0 (No VLAN)
    - Sees all the traffic on the virtual switch without VLAN tags
  - Portgroup with VLAN id ‘X’ (1-4094)
    - Sees all the traffic on the virtual switch with VLAN id ‘X’
  - Portgroup with VLAN id 4095
    - Sees all traffic on the virtual switch
    - Traffic is captured with VLAN tags
  - Promiscuous mode
    - Accept: All visible traffic
    - Reject: Only traffic matching the client MAC address

Questions ?

Presentation Download

Please remember to complete your
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and return it to the room monitors
as you exit the session

The presentation for this session can be downloaded at
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Enter the following to download (case-sensitive):

Username: cbv_rep
Password: cbvfor9v9r

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