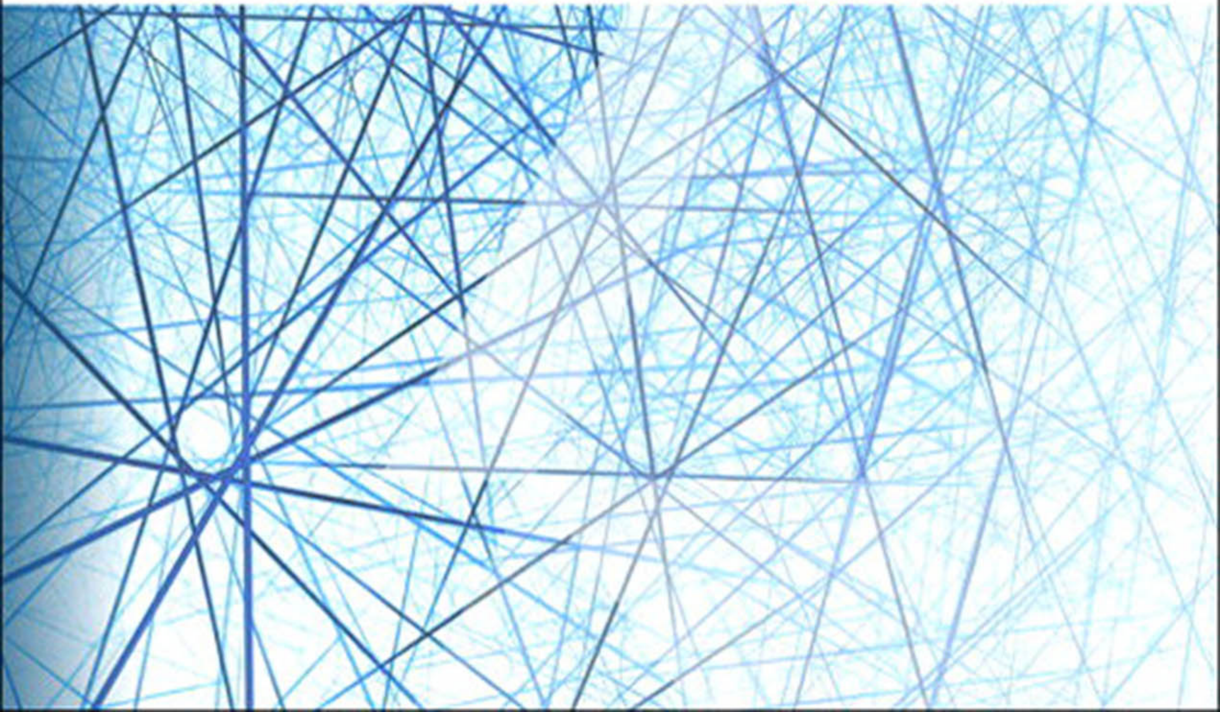
vmware PRESS

Networking for VMware® Administrators

Christopher Wahl
Steven Pantol



Networking for VMware Administrators

VMware Press is the official publisher of VMware books and training materials, which provide guidance on the critical topics facing today's technology professionals and students. Enterprises, as well as small- and medium-sized organizations, adopt virtualization as a more agile way of scaling IT to meet business needs. VMware Press provides proven, technically accurate information that will help them meet their goals for customizing, building, and maintaining their virtual environment.

With books, certification and study guides, video training, and learning tools produced by world-class architects and IT experts, VMware Press helps IT professionals master a diverse range of topics on virtualization and cloud computing. It is the official source of reference materials for preparing for the VMware Certified Professional Examination.

VMware Press is also pleased to have localization partners that can publish its products into more than 42 languages, including Chinese (Simplified), Chinese (Traditional), French, German, Greek, Hindi, Japanese, Korean, Polish, Russian, and Spanish.

For more information about VMware Press, please visit **vmwarepress.com**.

vmware® PRESS

pearsonitcertification.com/vmwarepress

Complete list of products • Podcasts • Articles • Newsletters

VMware® Press is a publishing alliance between Pearson and VMware, and is the official publisher of VMware books and training materials that provide guidance for the critical topics facing today's technology professionals and students.

With books, certification and study guides, video training, and learning tools produced by world-class architects and IT experts, VMware Press helps IT professionals master a diverse range of topics on virtualization and cloud computing, and is the official source of reference materials for completing the VMware certification exams.

Make sure to connect with us!
informit.com/socialconnect

vmware® | PEARSON IT CERTIFICATION | Safari Books Online

ALWAYS LEARNING PEARSON

This page intentionally left blank

Networking for VMware Administrators

Chris Wahl
Steve Pantol

vmware® PRESS

Upper Saddle River, NJ • Boston • Indianapolis • San Francisco
New York • Toronto • Montreal • London • Munich • Paris • Madrid
Capetown • Sydney • Tokyo • Singapore • Mexico City

Networking for VMware Administrators

Copyright © 2014 VMware, Inc.

Published by Pearson plc

Publishing as VMware Press

All rights reserved. Printed in the United States of America. This publication is protected by copyright, and permission must be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or likewise.

Library of Congress Control Number: 2014901956

ISBN-13: 978-0-13-351108-6

ISBN-10: 0-13-351108-1

Text printed in the United States on recycled paper at RR Donnelly in Crawfordsville, Indiana.

First Printing March 2014

All terms mentioned in this book that are known to be trademarks or service marks have been appropriately capitalized. The publisher cannot attest to the accuracy of this information. Use of a term in this book should not be regarded as affecting the validity of any trademark or service mark.

VMware terms are trademarks or registered trademarks of VMware in the United States, other countries, or both.

Warning and Disclaimer

Every effort has been made to make this book as complete and as accurate as possible, but no warranty or fitness is implied. The information provided is on an "as is" basis. The authors, VMware Press, VMware, and the publisher shall have neither liability nor responsibility to any person or entity with respect to any loss or damages arising from the information contained in this book.

The opinions expressed in this book belong to the authors and are not necessarily those of VMware.

Special Sales

For information about buying this title in bulk quantities, or for special sales opportunities (which may include electronic versions; custom cover designs; and content particular to your business, training goals, marketing focus, or branding interests), please contact our corporate sales department at corpsales@pearsoned.com or (800) 382-3419.

For government sales inquiries, please contact governmentsales@pearsoned.com.

For questions about sales outside the U.S., please contact international@pearsoned.com.

VMWARE PRESS PROGRAM MANAGER
Anand Sundaram

ASSOCIATE PUBLISHER
David Dusthimer

ACQUISITIONS EDITOR
Joan Murray

DEVELOPMENT EDITOR
Eleanor C. Bru

MANAGING EDITOR
Sandra Schroeder

PROJECT EDITOR
Seth Kerney

COPY EDITOR
Anne Goebel

PROOFREADER
Jess DeGabriele

INDEXER
Cheryl Lenser

EDITORIAL ASSISTANT
Vanessa Evans

BOOK DESIGNER
Gary Adair

COVER DESIGNER
Chuti Prasertsith

COMPOSITOR
Bumpy Design

To my wife Jennifer, for her steadfast patience and support
while I flailed around like a fish out of water trying to write this book.
—Chris Wahl

To my long-suffering wife, Kari. Sorry for the continued trouble.
—Steve Pantol

This page intentionally left blank

Contents

Foreword

Virtual networking has long been the Cinderella of server virtualization, as anyone reading VMware release notes can easily attest—with every new vSphere release, we get tons of new CPU/RAM optimization features, high availability improvements, better storage connectivity, and networking breadcrumbs.

The traditional jousting between networking and virtualization vendors and the corresponding lack of empathy between virtualization and networking teams in large IT shops definitely doesn't help. Virtualization vendors try to work around the traditional networking concepts (pretending, for example, that Spanning Tree Protocol [STP] and Link Aggregation Groups [LAG] don't exist), while routinely asking for mission-impossible feats such as long-distance bridging across multiple data centers. The resulting lack of cooperation from the networking team is hardly surprising, and unfamiliar concepts and terminology used by virtualization vendors definitely don't help, either.

The virtualization publishing ecosystem has adjusted to that mentality—we have great books on server virtualization management, troubleshooting, high availability, and DRS, but almost nothing on virtual networking and its interaction with the outside physical world. This glaring omission has finally been fixed—we've got a whole book dedicated solely to VMware networking.

Who should read this book? In my personal opinion, this book should be mandatory reading for anyone getting anywhere near a vSphere host. Server and virtualization administrators will get the baseline networking knowledge that will help them understand the intricacies and challenges their networking colleagues have to deal with on a daily basis, and networking engineers will finally have a fighting chance of understanding what goes on behind the scenes of point-and-click vCenter GUI. If nothing else, if you manage to persuade the virtualization *and* networking engineers in your company to read this book, they'll learn a common language they can use to discuss their needs, priorities, and challenges.

Although the book starts with rudimentary topics such as defining what a network is, it quickly dives into convoluted technical details of vSphere virtual networking, and I have to admit some of these details were new to me, even though I spent months reading vSphere documentation and researching actual ESXi behavior while creating my VMware Networking Technical Deep Dive webinar.

What will you get from the book? If you're a server or virtualization administrator and don't know much about networking, you'll learn the concepts you need to understand the data center networks and how vSphere virtual networking interacts with them. If you're a networking engineer, you'll get *the other perspective*—the view from the server side, and the details that will help you adjust the network edge to interact with vSphere hosts.

Finally, do keep in mind that *the other engineer* in your organization is not your enemy—she has a different perspective, different challenges, and different priorities and requirements. Statements such as "We must have this or we cannot do that" are rarely helpful in this context; it's way better to ask "Why would you need this?" or "What business problem are you trying to solve?"—and this book just might be a piece of the puzzle that will help you bridge the communication gap.

Ivan Pepelnjak

CCIE #1354 Emeritus

ipSpace.net

Introduction

In many organizations, there is still no Virtualization Team, or even a dedicated Virtualization Person. The care and feeding of a vSphere environment often falls under the "Perform other duties as assigned" bullet in the job description of existing server or storage administrators.

Virtualization is a complex subject, interdisciplinary by nature, and truly "getting it" requires a solid understanding of servers, storage, and networking. But because new technologies are often managed by whoever arrived to the meeting last, skill gaps are bound to come up. In the authors' experience, networking is the subject most foreign to admins that inherit a vSphere environment. Server and storage teams tend to work rather closely, with the network hiding behind a curtain of patch panels. This book is intended to help vSphere admins bridge that gap.

This book is not intended to be a study guide for any particular certification. If your goal is Network+, CCENT, or beyond, there are other, more comprehensive options available.

Part I, "Physical Networking 101," is intended to build a foundation of networking knowledge, starting with the very basics of connectivity and building up to routing and switching. It provides the background and jargon necessary for you to communicate effectively with your network team as you scale up your virtualization efforts.

In Part II, "Virtual Switching," we look at virtual networking, explaining how and where it differs from the physical world we built up in Part I. We go on a guided tour of building virtual networks, starting with real-world requirements, and review the virtual and physical network configuration steps necessary to meet them.

In Part III, "You Got Your Storage in My Networking: IP Storage," we add storage into the mix, using the same approach from Part II to look at iSCSI and NFS configurations.

Motivation for Writing This Book

Chris: Aside from a grandiose ambition to cross "write a book" off my bucket list, there is something inherently romantic about the idea of passing one's experiences down to the next generation of technical professionals. The field of networking is like sailing in dark and uncharted waters, with little islands of knowledge along the way. Having made the voyage, I felt it best to return as a guide and see if I could both help others through and learn more on the second go-round for myself.

Steve: What Chris said, but maybe less flowery. And it seemed like a good idea at the time.

Who Should Read This Book

This book is targeted at IT professionals who are involved in the care and feeding of a VMware vSphere environment. These administrators often have strong server or storage backgrounds but lack exposure to core networking concepts. As virtualization is interdisciplinary in nature, it is important for vSphere administrators to have a holistic understanding of the technologies supporting their environment.

How to Use This Book

This book is split into 19 chapters as described here:

- **Part I, "Physical Networking 101"**
  - **Chapter 1, "The Very Basics":** This chapter provides a high-level introduction to networking concepts.
  - **Chapter 2, "A Tale of Two Network Models":** This chapter describes the purpose of network models and describes the two major flavors.
  - **Chapter 3, "Ethernet Networks":** This chapter introduces the basics of Ethernet networks.
  - **Chapter 4, "Advanced Layer 2":** This chapter builds upon the previous chapter by diving into more advanced Ethernet concepts including VLANs, switch port types, Spanning Tree Protocol, and Link Aggregation.
  - **Chapter 5, "Layer 3":** This chapter describes the IP protocol, Layer 3 networking, and supporting applications.
  - **Chapter 6, "Converged Infrastructure (CI)":** This chapter provides a brief overview of converged infrastructure and describes example platforms.
- **Part II, "Virtual Switching"**
  - **Chapter 7, "How Virtual Switching Differs from Physical Switching":** This chapter highlights the differences in the mechanics and execution between physical switches as described in Part I and the virtual switches that are the focus of the rest of the book.
  - **Chapter 8, "vSphere Standard Switch":** This chapter covers the features available with the vSphere Standard Switch.
  - **Chapter 9, "vSphere Distributed Switch":** This chapter covers the features available with the vSphere Distributed Switch.

- **Chapter 10, "Third Party Switches—1000v":** This chapter covers the features available with the Cisco Nexus 1000v virtual switch.
- **Chapter 11, "Lab Scenario":** This chapter introduces the lab scenario that is used in Chapters 12 and 13, guiding the reader through a design exercise.
- **Chapter 12, "Standard vSwitch Design":** This chapter describes the configuration steps necessary to configure the Standard vSwitch to support the use case defined in Chapter 11.
- **Chapter 13, "Distributed vSwitch Design":** This chapter describes the configuration steps necessary to configure the Distributed vSwitch to support the use case defined in Chapter 11, with a focus on the feature differences between the Distributed and Standard vSwitches.

- **Part III, "You Got Your Storage in My Networking: IP Storage"**
  - **Chapter 14, "iSCSI General Use Cases":** This chapter introduces the concepts behind iSCSI and describes an example use case.
  - **Chapter 15, "iSCSI Design and Configuration":** This chapter describes the configuration steps necessary to configure iSCSI to support the use case defined in Chapter 14.
  - **Chapter 16, "NFS General Use Cases":** This chapter introduces the concepts behind NFS and describes an example use case.
  - **Chapter 17, "NFS Design and Configuration":** This chapter describes the configuration steps necessary to configure NFS to support the use case defined in Chapter 16.
- **Part IV, "Other Design Scenarios"**
  - **Chapter 18, "Additional vSwitch Design Scenarios":** This chapter describes different design options that could be considered for varying hardware configurations.
  - **Chapter 19, "Multi-NIC vMotion Architecture":** This chapter introduces the concepts behind Multi-NIC vMotion and describes the steps necessary to configure it for a sample use case.
- **Appendix A, "Networking for VMware Administrators: The VMware User Group":** This appendix is a call to action introducing the VMware User Group as a means of harnessing the power of the greater VMware community and encouraging the reader to get involved.

About the Authors

Chris Wahl has acquired more than a decade of IT experience in enterprise infrastructure design, implementation, and administration. He has provided architectural and engineering expertise in a variety of virtualization, data center, and private cloud-based engagements while working with high performance technical teams in tiered data center environments. He currently holds the title of Senior Technical Architect at Ahead, a consulting firm based out of Chicago.

Chris holds well over 30 active industry certifications, including the rare VMware Certified Design Expert (VCDX #104), and is a recognized VMware vExpert. He also works to give back to the community as both an active "Master" user and moderator of the VMware Technology Network (VMTN) and as a Leader of the Chicago VMware User Group (VMUG).

As an independent blogger for the award winning "Wahl Network," Chris focuses on creating content that revolves around virtualization, converged infrastructure, and evangelizing products and services that benefit the technology community. Over the past several years, he has published hundreds of articles and was voted the "Favorite Independent Blogger" by vSphere-Land for 2012. Chris also travels globally to speak at industry events, provide subject matter expertise, and offer perspectives as a technical analyst.

Steve Pantol has spent the last 14 years wearing various technical hats, with the last seven or so focused on assorted VMware technologies. He holds numerous technical certifications and is working toward VCDX—if only to stop Wahl from lording it over him. He is a Senior Technical Architect at Ahead, working to build better data centers and drive adoption of cloud technologies.

Acknowledgments

Chris would like to thank the people that helped him get to a point in his career where he could share knowledge around virtual networking with the technical community. It has taken years of trial and error, resulting in many successes and failures, to reach this point. While there were many people providing guidance and a leg up along the way, he would like to specifically thank his past mentors Wayne Balogh, Sean Murphy, Matt Lattanzio, and Pam Cox, along with his parents Dawn and Matt for their steadfast support towards a career in technology. Additionally, an immeasurable thank you to his supportive spouse Jennifer for providing positive energy and inspiration on a daily basis.

Steve would like to thank his wife, Kari, and their numerous children—Kurt, Avery, and Ben—for putting up with him, both in general and as it relates to this project. And his parents, Don and Betty, for spending so much early 90s money on computers, and not yelling when he took them apart. Also, a special thank you to Xfinity On-Demand, particularly the Sprout and Disney Junior networks, for shouldering much of the burden of parenting over the last several months.

We both would like to thank everyone at our employer, Ahead, including Mitch Northcutt, Eric Kaplan, Paul Bostjancic, and Mike Mills, for their technical and logistical support. Also our amazing technical reviewers, Doug Baer, Scott Winger, and Trevor Roberts, and the team at VMware Press, Joan Murray, Ellie Bru, and Seth Kerney, who have all been tireless in working and reworking the manuscript to make it perfect.

About the Reviewers

Doug Baer is an Infrastructure Architect on the Hands-on Labs team at VMware. His nearly 20 years in IT have spanned a variety of roles including consulting, software development, system administration, network and storage infrastructure solutions, training, and lab management. Doug earned a Bachelor of Science in Computer Science from the University of Arizona in Tucson, Arizona, and holds several top-level industry certifications, including VCDX #19 and HP's Master ASE Cloud and Datacenter Architect (#14).

You can find him working in the Hands-on labs at VMware's large events, presenting at VMware User Group events, writing on the VMware blogs (http://blogs.vmware.com/), or answering questions on the VMware Community forums. If you look hard enough, you might even find him as "Trevor" in videos on the Hands-on labs site. In his free time, Doug likes to get away from technology and spend time hiking with his family or running on the roads and trails all over Arizona.

Trevor Roberts Jr. is a Senior IT Architect with Cisco who enjoys helping customers achieve success with Virtualization and Cloud solutions. In his spare time, Trevor shares his insights on datacenter technologies at www.VMTrooper.com, via the Professional OpenStack and Professional VMware podcasts, and through Twitter @VMTrooper. Trevor is also currently authoring a manuscript on the topic of DevOps for VMware Administrators.

Scott Winger is an aspiring writer who has been a computing technologist for a large Midwest university since 1987. He has a degree in Mathematics and studied Computer Architecture, Operating Systems, Programming Languages and Compilers, Database Management Systems, Networking, and Numerical Methods at UW-Madison. He is a nationally recognized teacher of the sailor's arts and teaches various networking and computing classes at a nearby Cisco Academy and Technical College. Scott earned his most recent certification, VMware Certified Professional, in May 2013 and is in constant pursuit of additional certifications from Cisco, Microsoft, and VMware.

We Want to Hear from You!

As the reader of this book, *you* are our most important critic and commentator. We value your opinion and want to know what we're doing right, what we could do better, what areas you'd like to see us publish in, and any other words of wisdom you're willing to pass our way.

We welcome your comments. You can email or write us directly to let us know what you did or didn't like about this book—as well as what we can do to make our books better.

Please note that we cannot help you with technical problems related to the topic of this book.

When you write, please be sure to include this book's title and authors as well as your name, email address, and phone number. We will carefully review your comments and share them with the authors and editors who worked on the book.

Email: VMwarePress@vmware.com

Mail: VMware Press
ATTN: Reader Feedback
800 East 96th Street
Indianapolis, IN 46240 USA

Reader Services

Visit our website and register this book at www.informit.com/title/9780133511086 for convenient access to any updates, downloads, or errata that might be available for this book.

This page intentionally left blank

Chapter 8

vSphere Standard Switch

Key Concepts

- Control and Data Planes
- Virtual Ports
- vSwitch Security
- Traffic Shaping
- NIC Teaming and Failover
- VMkernel Ports
- Port Groups

Introduction

A VMware ESXi server cannot do much of anything worthwhile without some means of getting network traffic to and from the VMs it hosts. Fortunately, VMware realized this and has thoughtfully provided two solutions to this problem, the vSphere Standard Switch and the vSphere Distributed Switch. This chapter focuses on the former, the original recipe vSwitch that is included with every license level. Don't let the "standard" part of the Standard Switch fool you—it includes a bunch of great features to help you shuffle traffic around your network. With that said, let's look at what makes a VMware Standard Switch tick.

The vSphere Standard Switch

The goal of VMware's Standard Switch is to allow network traffic to flow in any scenario. This could mean that the ESXi host is not connected to a vCenter server at all, which is typically referred to as a "standalone" or "vSphere Hypervisor" install of vSphere. In this case, there's no higher level of management than the host itself, so the standard level switch needs to be able to function with nothing more than the host telling it what to do.

TIP

If you think about it deeper, when you first install VMware ESXi onto a server, it is a blank slate—it has no name, IP, or DNS information. While there are ways to script the install to auto-assign these identities, no assumptions can be made. This is another reason why the standard vSwitch must be able to operate with nothing more fancy than a standalone installation of ESXi.

Plane English

Before getting too far into how the Standard Switch works, we need to introduce a bit of terminology. When describing switch functions, we often use the terms "control plane" and "data plane." Control plane traffic and functions can best be thought of as traffic *to* the switch, and data plane traffic is traffic *through* the switch. Management, monitoring, and configuration traffic concerning the switch is control plane traffic. Frames passing from a virtual machine (VM) out to the rest of the world would be data plane traffic.

In your typical physical, top-of-rack style switch, control and data planes live within the same piece of equipment. With virtual switches, these functions can be separated.

Control Plane

The *control plane* of a standard vSwitch resides on the VMware host. That is, any manipulation of the vSwitch configuration, number of ports, and the way that traffic is moved around are all part of the host's responsibilities. More specifically, it's the job of the hypervisor kernel (called the VMkernel) to make sure that the vSwitch is configured and operational.

As such, even when you cluster a bunch of VMware hosts together, each host is responsible for its own standard vSwitches. In the case of a vCenter failure, every host's standard vSwitch would still be configurable by connecting the vSphere client directly to the host.

Data Plane

Every Standard vSwitch on a host is responsible for switching frames, which means that the *data plane* is a host's responsibility. As data enters the host NICs, which form the uplinks for a standard vSwitch, the VMkernel makes sure that the frames get to the appropriate destination. Sometimes this means that the traffic gets ignored, especially in the case of external traffic that enters the vSwitch with an unknown destination MAC address.

vSwitch Properties

Every vSwitch has two basic properties that can be configured in order to meet the requirements of your design and network's maximum transmission size.

Ports

Ports indicate the number of virtual ports that will be kept in memory, tracked, and made available to VMs, VMkernel ports, and uplinks that reside on the host. One weakness of a standard vSwitch is the requirement that the ESXi host be restarted if you change the number of ports. Prior to vSphere 4.1, the default number of vSwitch ports was only 56, leading many a green VMware administrator to hit that limit before realizing it was something that could be changed. Over time, VMware listened to the woes of virtualization administrators and, in vSphere 4.1, the default number of ports assigned to a standard vSwitch has been changed to 128, allowing some breathing room. An administrator can adjust the number of ports by powers of 2, from 128 to 256 and so on, all the way up to 4,096 possible ports.

Figure 8.1 shows the default vSwitch properties dialog in the vSphere Web Client.

REAL WORLD EXAMPLE

If you look at the port count on the classic vSphere client, you might notice that it shows 8 fewer ports (120) for the default. Hey, who stole my ports? Don't worry, this is the expected behavior. The hypervisor always reserves 8 ports for overhead activities such as network discovery, Cisco Discovery Protocol (CDP) traffic, and physical uplinks. On the newer vSphere web client, the actual port counts are shown.

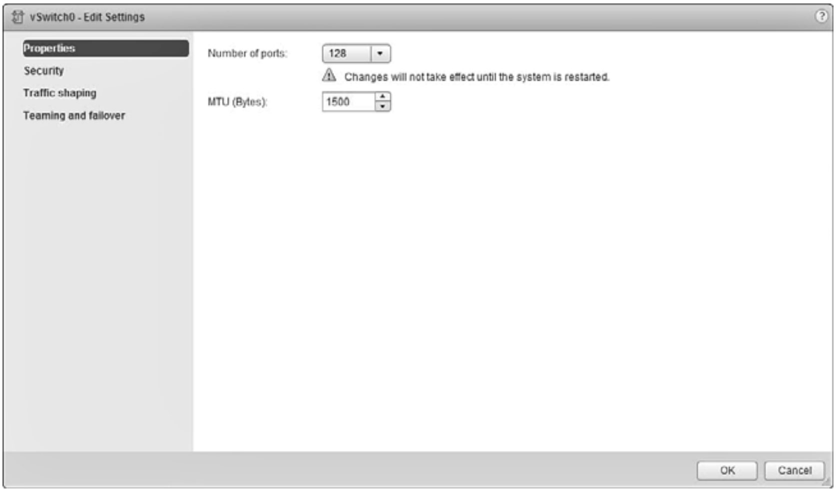


Figure 8.1 The default vSwitch properties

Maximum Transmission Unit (MTU)

The other item that you can configure is the MTU, which is the maximum amount of data that can be crammed into a frame's payload segment. By default, this is 1,500 bytes, which is the default for just about any networking device you can buy. You can safely assume that all of the physical equipment that runs northbound of the vSwitch will support a 1,500 MTU or larger, which avoids unnecessary packet fragmentation.

There's also an option to increase this size and set it to a "jumbo" size. We do love our silly names in this industry. Jumbo frames are just frames larger than the default size of 1,500. Even setting an MTU of 1,501 is technically enabling jumbo frames. Tremble before the mighty, slightly larger frame.

Most of the time, though, the term *jumbo frame* refers to a frame with an MTU of 9,000 or higher, though 9,000 is the maximum MTU ESXi will support. If you are talking to a network engineer and want to get an idea of what MTU size to set on your vSwitch, ask specifically what the MTU value is—don't just ask if he or she is running jumbo frames. This avoids any confusion.

REAL WORLD EXAMPLE

We've done a lot of work with people who want to enable jumbo frames thinking that a larger number is by default going to increase performance. This is not always true, and in some cases, enabling jumbo frames can actually hurt performance. It's also incredibly difficult to make sure that all of the physical networking equipment is properly configured for a jumbo frame size. Make sure that you have a solid technical reason, with performance testing, before you worry about increasing your MTU size on your infrastructure.

Security

The security settings on a vSwitch are probably one of the most misunderstood portions of a vSwitch configuration. There are three settings available for tuning: promiscuous mode, MAC address changes, and forged transmits, as shown in Figure 8.2.

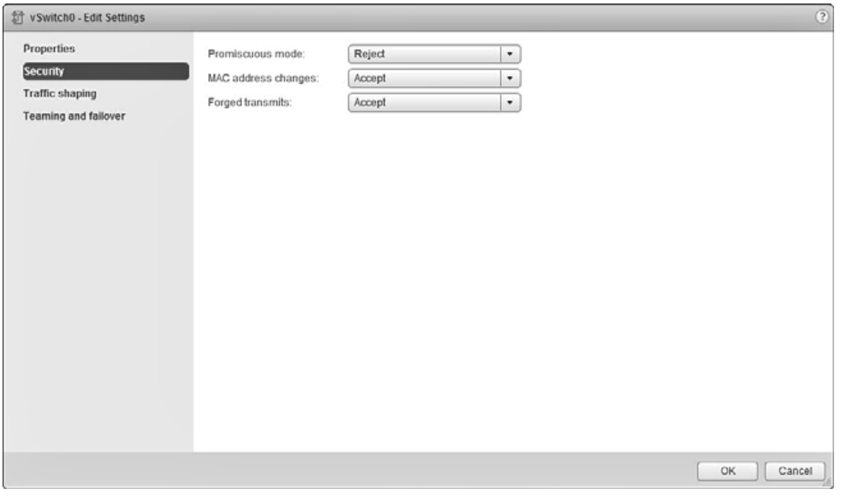


Figure 8.2 Security settings on a vSwitch

Promiscuous Mode

If you think back to when we covered physical switching, you'll probably recall that one major advantage to it is that we have the ability to switch traffic directly to a single destination MAC address. Unless the traffic is being flooded, broadcast, or specifically intended for a destination, devices on the network do not "see" the other traffic floating across the switch. This is great for most use cases as it provides for greater scalability and improved performance of the network, and is the default behavior on a standard vSwitch.

There are some situations where we really do want a VM to see traffic that is intended for another device. Imagine having some sort of network monitoring VM that needs to sniff traffic. This is where Promiscuous Mode comes in handy. By setting it to Accept, we are ordering the vSwitch to share traffic on each VLAN among other VMs on the same VLAN.

> **PITFALL**
>
> Promiscuous mode does not allow a VM to see traffic on VLANs that aren't specified by the port group. It can still only see traffic for the VLAN(s) that it belongs to. This is a very common misconception.

MAC Address Changes

The idea of MAC Address Changes tends to confuse a lot of people, so we'll go deep into this one. First, what exactly is a MAC Address Change from a vSwitch perspective? To understand this, you must first know more about how the switch keeps track of MAC addresses for VMs.

To begin with, every VM has three different types of MAC addresses: the Initial, Effective, and Runtime MAC addresses:

- The *Initial MAC address* is configured on the virtual network adapter inside the VM. This is something you either let vSphere decide for you when the virtual NIC is created or manually set yourself by changing that vSphere-provided value. It is very similar to a physical NIC's burned-in address (BIA).
- The *Effective MAC address* is configured within the VM by the guest operating system (OS). Typically, the guest OS just uses the Initial MAC address, much like your PC will by default use the BIA or your NIC.
- The *Runtime MAC address* is the actual live address that is being seen by the vSwitch port.

Figure 8.3 shows the Runtime MAC address of a VM in the vSphere Web Client.

So, now that you're a MAC address expert, let's go back in and discuss how the vSwitch polices MAC Address Changes.

When set to "Accept," the vSwitch allows the Initial MAC address to differ from the Effective MAC address, meaning the guest OS has been allowed to change the MAC address for itself. Typically, we don't want this to happen as a malicious user could try to impersonate another VM by using the same MAC address, but there are use cases, such as with Microsoft Network Load Balancing (NLB) where it makes sense.

Figure 8.3 The Runtime MAC address of a VM

When set to "Reject," the vSwitch will disable the port if it sees that the guest OS is trying to change the Effective MAC address to something other than the Initial MAC address. The port will no longer receive traffic until you either change the security policy or make sure that the Effective MAC address is the same value as the Initial MAC address.

To sum it up, the MAC Address Changes policy is focused entirely on whether or not a VM (or even a VMkernel port) is allowed to change the MAC address it uses for receiving traffic. The next section covers sending traffic.

Forged Transmits

Very similar to the MAC Address Changes policy, the Forged Transmits policy is concerned with MAC Address Changes, but only as it concerns transmitting traffic.

If set to "Accept," the VM can put in any MAC address it wishes into the "source address" field of a Layer 2 frame. The vSwitch port will just happily let those frames move along to their destination.

If the policy is set to "Reject," the port will interrogate all the traffic that is generated by the VM. The policy will check to see if the source MAC address field has been tampered with. As long as the source MAC field is the same as the Effective MAC address, the frame is allowed by the port. However, if it finds a non-matching MAC address, the frame is dropped.

It's very common to see issues with the Forged Transmit policy when doing nested virtualization. *Nesting* is the term used to describe running the ESXi hypervisor inside a VM, which then runs other nested VMs with their own unique MAC addresses. The many different MAC addresses will be seen by the port used by the nested hypervisor VM because the nested guest VMs are sending traffic. In this case, you would have to configure the policy for Forged Transmits to Accept.

Figure 8.4 illustrates this process.

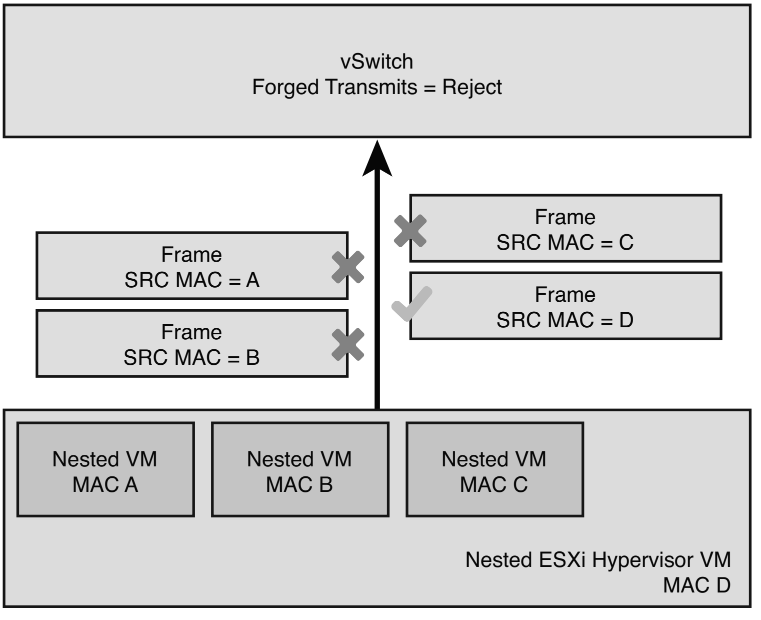


Figure 8.4 Nested VMs cannot send traffic without accepting forged transmits

Discovery

When you have a working vSwitch in your environment, chances are you're going to want to make sure that you can participate in one of a few different monitoring methods to determine the complex topology of switches. We sometimes refer to this as the "neighborhood" of switching.

Most switches are connected to at least one other switch, forming a web of switches that can all talk to one another. Using a discovery protocol, we can allow these switches, both physical and virtual, to understand who their neighbors are.

NOTE

An easy way to make friends with your networking department is to enable discovery on your vSwitches. We find that many have either never heard of the feature or are hesitant to enable it. Make sure your security team is okay with you using a discovery protocol before turning it on, but once on, it makes understanding the neighborhood of physical and virtual switches dramatically easier for everyone!

Cisco Discovery Protocol (CDP)

The VMware standard vSwitch supports only one single protocol for discovery, the Cisco Discovery Protocol. Can you guess which switch manufacturer uses this protocol? We'll give you a hint—it's not Brocade.

CDP is a proprietary way to allow switches to chat with one another to figure out who they are plugged into. It's not required for traffic to flow, but it does give administrators and engineers a great way to see what device is at the end of a plugged-in port. It also updates itself in real time, meaning it has a lot more value than trying to keep your configuration in a spreadsheet or some other manual method. CDP is enabled by default on Standard Switches. Figure 8.5 shows the output of the `show cdp neighbors` command on a 3550 switch to which a Standard Switch has been connected.

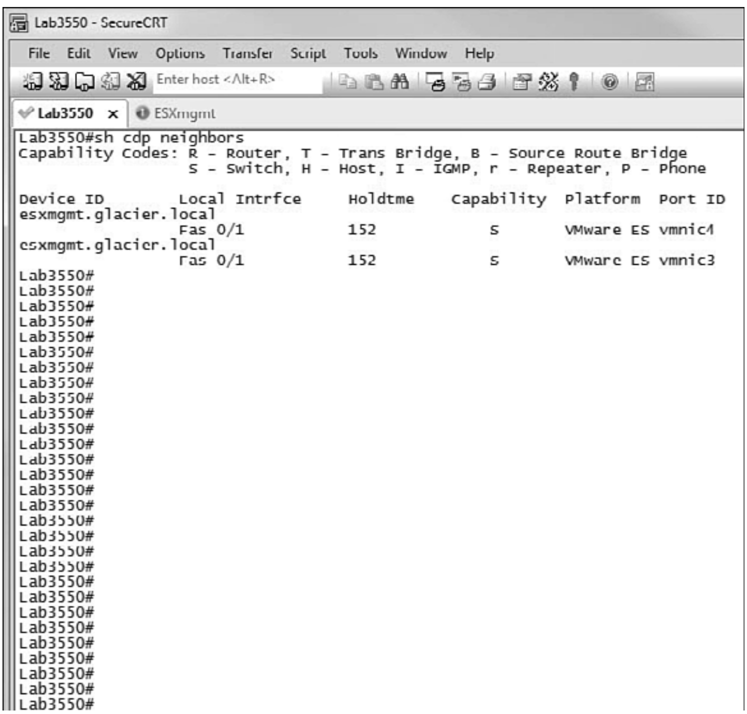


Figure 8.5 CDP information on a Cisco 3550 switch connected to two vSwitch uplink ports

Traffic Shaping

Traffic shaping is the ability to control the quantity of traffic that is allowed to flow across a link. That is, rather than letting the traffic go as fast as it possibly can, you can set limits to how much traffic can be sent.

Within a standard vSwitch, you can only enforce traffic shaping on outbound traffic that is being sent out of an object—such as a VM or VMkernel port—toward another object. This is referred to by VMware as "ingress traffic" and refers to the fact that data is coming into the vSwitch by way of the virtual ports. Later, we cover how to set "egress traffic" shaping, which is the control of traffic being received by a port group headed toward a VM or VMkernel port, when we start talking about the distributed switch in the next chapter.

Traffic shaping consists of three different control points, as shown in Figure 8.6.

- **Average bandwidth (Kbps)**: The average amount of bandwidth, measured in kilobits per second (Kbps), that you allow the switch to send. There might be short periods where the traffic slightly exceeds this value, since it is an average over time, but for the most part, it will be enforced and traffic will go no faster than the defined speed limit set here.
- **Peak bandwidth (Kbps)**: The maximum amount of bandwidth that the switch is allowed to let through. The use of the peak bandwidth value is determined by how often we've hit the average bandwidth limitation. Whenever the actual traffic volume is lower than the average bandwidth limit, we gain what is called a "burst bonus" which can be any number of bytes up to the limit set by the burst size value (covered next).

  This bonus can be used when there is a pent-up traffic demand to let more traffic flow through the switch using data sizes dictated by the burst size value.
- **Burst size (KB)**: This is an often misunderstood value, so we'll go into detail. The burst size is the actual amount of "burstable" data that is allowed to be transmitted at the peak bandwidth rate in kilobytes. Think of the burst bonus as a network traffic savings account. And the burst size is the maximum number of bytes that can go into that account. So, when you need to send more traffic than the average bandwidth value allows, you transmit a burst of traffic, which is more than the allowed average bandwidth. But this burst, which always stays at or below the allowable peak bandwidth, will be forced to end when the number of bytes in your traffic savings account, your burst bonus, reaches zero.

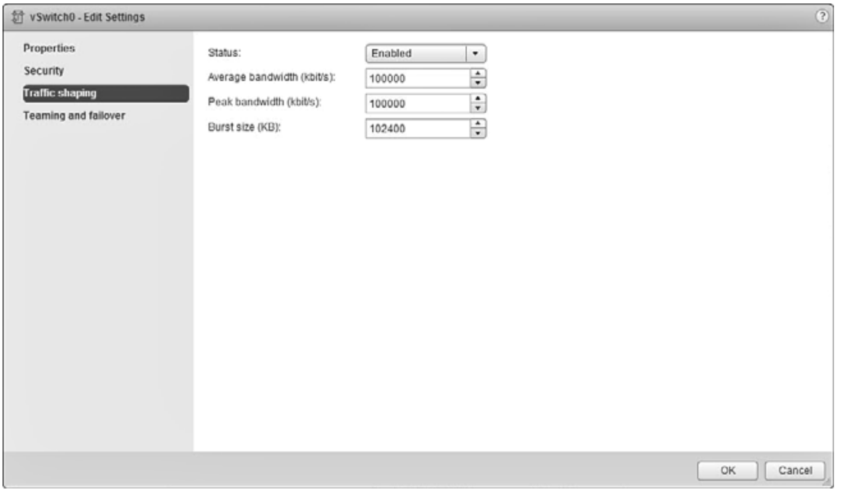


Figure 8.6 A look at the traffic-shaping controls

Figure 8.7 is an example showing a period of average traffic with a burst of peak bandwidth in the middle. You can determine how long the traffic will be able to burst by taking the burst size (KB) amount divided by the peak bandwidth (kbps).

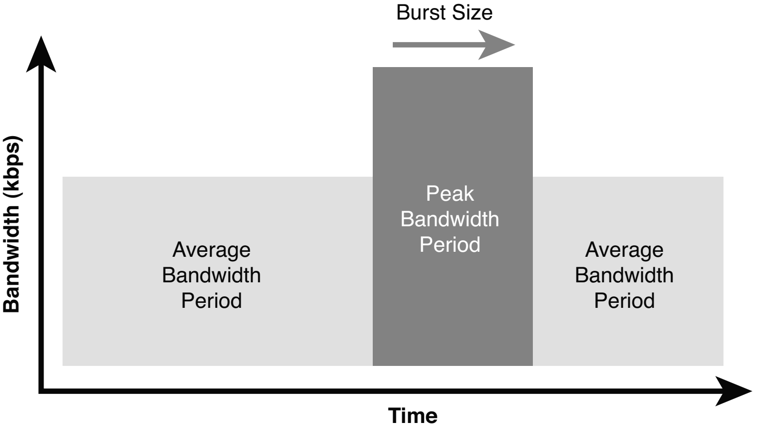


Figure 8.7 A traffic-shaping graph showing average and peak bandwidth

Making changes to the traffic-shaping values will instantly begin enforcing the limitations on the switch—there is no restart or warm-up period.

Traffic Shaping Math

Here's a concrete example showing how to calculate how long traffic will peak in a "best case" scenario:

- Let's assume, for easy math, that you set the average bandwidth value to 1,000 Kbps.
- You also set the peak bandwidth to 2,000 Kbps, which is twice the value of the average bandwidth.
- Finally, you configure the burst size to 1,000 kilobytes (KB). Hint—don't forget that there are 8 bits in a byte, which means that 1,000 KB is 8,000 Kb. Big "B" is for bytes and little "b" is for bits.

If the burst bonus is completely full, which would mean that it's the full value of the burst size (8,000 Kb), then you could peak for 4 seconds:

8,000 Kb burst size / 2,000 Kbps peak bandwidth = 8 / 2 = 4 seconds

NIC Teaming

Let's take a well-deserved break from networking math for a moment and shift into the fun world of NIC teaming. The concept of teaming goes by many different names: bonding, grouping, and trunking to name a few. Really, it just means that we're taking multiple physical NICs on a given ESXi host and combining them into a single logical link that provides bandwidth aggregation and redundancy to a vSwitch. You might think that this sounds a little bit like port channels from earlier in the book. And you're partially right—the goal is very similar, but the methods are vastly different.

Figure 8.8 shows all the configuration options for teaming and failover.

Let's go over all of the configuration options for NIC teaming within a vSwitch. These options are a bit more relevant when your vSwitch is using multiple uplinks but are still valid configuration points no matter the quantity of uplinks.

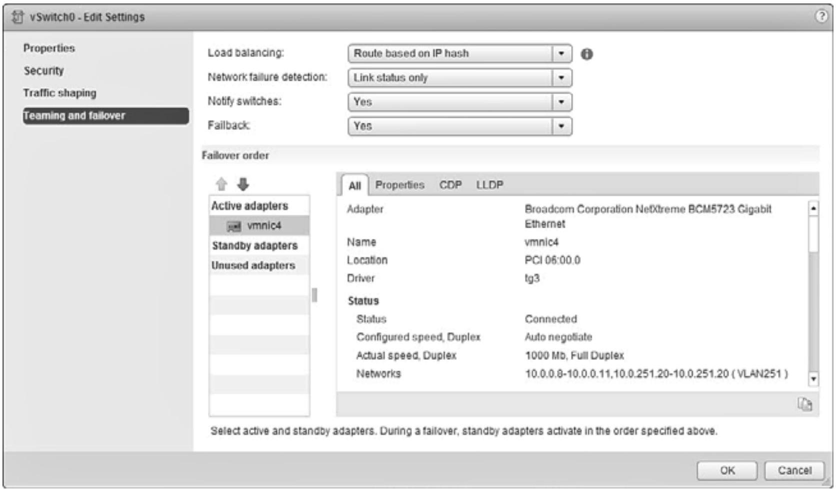


Figure 8.8 Configuration options for teaming and failover, as viewed from the vSphere Web Client

Load Balancing

The first point of interest is the *load-balancing policy*. This is basically how we tell the vSwitch to handle outbound traffic, and there are four choices on a standard vSwitch:

1. Route based on the originating virtual port
2. Route based on IP hash
3. Route based on source MAC hash
4. Use explicit failover order

Keep in mind that we're not concerned with the inbound traffic because that's not within our control. Traffic arrives on whatever uplink the upstream switch decided to put it on, and the vSwitch is only responsible for making sure it reaches its destination.

The first option, *route based on the originating virtual port*, is the default selection for a new vSwitch. Every VM and VMkernel port on a vSwitch is connected to a virtual port. When the vSwitch receives traffic from either of these objects, it assigns the virtual port an uplink and uses it for traffic. The chosen uplink will typically not change unless there is an uplink failure, the VM changes power state, or the VM is migrated around via vMotion.

The second option, *route based on IP hash*, is used in conjunction with a link aggregation group (LAG), also called an EtherChannel or port channel. When traffic enters the vSwitch, the load-balancing policy will create a hash value of the source and destination IP addresses in the packet. The resulting hash value dictates which uplink will be used.

The third option, *route based on source MAC hash*, is similar to the IP hash idea, except the policy examines only the source MAC address in the Ethernet frame. To be honest, we have rarely seen this policy used in a production environment, but it can be handy for a nested hypervisor VM to help balance its nested VM traffic over multiple uplinks.

The fourth and final option, *use explicit failover order*, really doesn't do any sort of load balancing. Instead, the first Active NIC on the list is used. If that one fails, the next Active NIC on the list is used, and so on, until you reach the Standby NICs. Keep in mind that if you select the Explicit Failover option and you have a vSwitch with many uplinks, only one of them will be actively used at any given time. Use this policy only in circumstances where using only one link rather than load balancing over all links is desired or required.

NOTE

In almost all cases, the route based on the originating virtual port is more than adequate. Don't try to get fancy with an exotic load-balancing policy unless you see an issue where the majority of traffic is being sent down the same uplink and other uplinks are relatively quiet. Remember our motto—the simplest designs are almost always the best designs.

A single VM will not be able to take advantage of more than a single uplink in most circumstances. If you provide a pair of 1 Gb Ethernet uplinks to your vSwitch, a VM will still only use one of those uplinks at a time. There are exceptions to this concept, such as when a VM has multiple virtual NICs attached on a vSwitch with IP hash, but are relatively rare to see in production environments.

Network Failure Detection

When a network link fails (and they definitely do), the vSwitch is aware of the failure because the link status reports the link as being down. This can usually be verified by seeing if anyone tripped over the cable or mistakenly unplugged the wrong one. In most cases, this is good enough to satisfy your needs and the default configuration of "link status only" for the network failure detection is good enough.

But what if you want to determine a failure further up the network, such as a failure beyond your upstream connected switch? This is where beacon probing might be able to help you out. *Beacon probing* is actually a great term because it does roughly what it sounds like it should do. A beacon is regularly sent out from the vSwitch through its uplinks to see if the other uplinks can "hear" it.

Figure 8.9 shows an example of a vSwitch with three uplinks. When Uplink1 sends out a beacon that Uplink2 receives but Uplink3 does not, this is because the upstream aggregation switch 2 is down, and therefore, the traffic is unable to reach Uplink3.

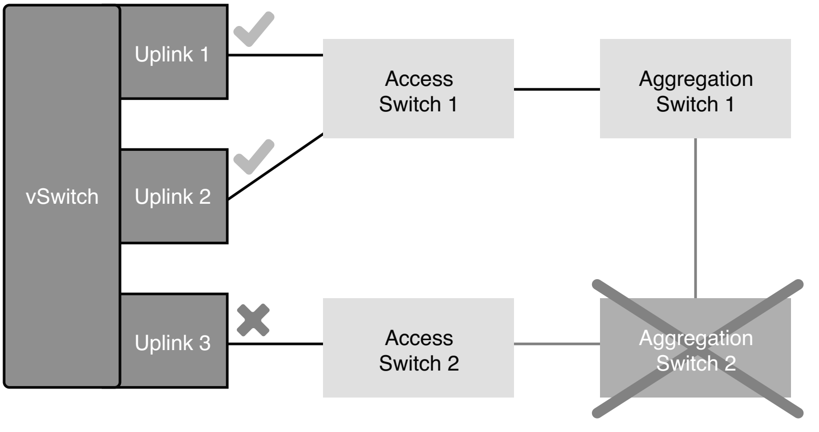


Figure 8.9 An example where beacon probing finds upstream switch failures

Are you curious why we use an example with three uplinks? Imagine you only had two uplinks and sent out a beacon that the other uplink did not hear. Does the sending uplink have a failure, or does the receiving uplink have a failure? It's impossible to know who is at fault. Therefore, you need at least three uplinks in order for beacon probing to work.

NOTE

Beacon probing has become less and less valuable in most environments, especially with the advent of converged infrastructure and the use of 10 GbE-enabled blades with only two NICs or mezzanine cards. Most modern datacenters connect all their servers and switches in a redundant fashion, where an upstream switch failure would have no effect on network traffic. This isn't to say that there aren't use cases remaining for beacon probing, but it's relatively rare. Also, never turn on beacon probing when the uplinks are connected to a LAG, as the hashing algorithm might divert your beacons to the wrong uplink and trigger a false positive failure.

Notify Switches

The Notify Switches configuration is a bit mystifying at first. Notify the switches about what, exactly? By default, it's set to "Yes," and as we cover here, that's almost always a good thing.

Remember that all of your upstream physical switches have a MAC address table that they use to map ports to MAC addresses. This avoids the need to flood their ports—which means sending frames to all ports except the port they arrived on (which is the required action when a frame's destination MAC address doesn't appear in the switch's MAC address table).

But what happens when one of your uplinks in a vSwitch fails and all of the VMs begin using a new uplink? The upstream physical switch would have no idea which port the VM is now using and would have to resort to flooding the ports or wait for the VM to send some traffic so it can re-learn the new port. Instead, the Notify Switches option speeds things along by sending Reverse Address Resolution Protocol (RARP) frames to the upstream physical switch on behalf of the VM or VMs so that upstream switch updates its MAC address table. This is all done before frames start arriving from the newly vMotioned VM, the newly powered-on VM, or from the VMs that are behind the uplink port that failed and was replaced.

These RARP announcements are just a fancy way of saying that the ESXi host will send out a special update letting the upstream physical switch know that the MAC address is now on a new uplink so that the switch will update its MAC address table before actually needing to send frames to that MAC address. It's sort of like ESXi is shouting to the upstream physical switch and saying, "Hey! This VM is over here now!"

Failback

Since we're already on the topic of an uplink failure, let's talk about Failback. If you have a Standby NIC in your NIC Team, it will become Active if there are no more Active NICs in the team. Basically, it will provide some hardware redundancy while you go figure out what went wrong with the failed NIC. When you fix the problem with the failed Active NIC, the Failback setting determines if the previously failed Active NIC should now be returned to Active duty.

If you set this value to Yes, the now-operational NIC will immediately go back to being Active again, and the Standby NIC returns to being Standby. Things are returned back to the way they were before the failure.

If you choose the No value, the replaced NIC will simply remain inactive until either another NIC fails or you return it to Active status.

Failover Order

The final section in a NIC team configuration is the failover order. It consists of three different adapter states:

- **Active adapters**: Adapters that are Actively used to pass along traffic.
- **Standby adapters**: These adapters will only become Active if the defined Active adapters have failed.
- **Unused adapters**: Adapters that will never be used by the vSwitch, even if all the Active and Standby adapters have failed.

While the Standby and Unused statuses do have value for some specific configurations, such as with balancing vMotion and management traffic on a specific pair of uplinks, it's common to just set all the adapters to Active and let the load-balancing policy do the rest. We get more into the weeds on adapter states later on in the book, especially when we start talking about iSCSI design and configuration in Part 3, "You Got Your Storage in My Networking: IP Storage."

Hierarchy Overrides

One really great feature of a vSwitch is the ability to leverage overrides where necessary. You won't see any override information on the vSwitch itself, but they are available on the VMkernel ports and VM port groups, which are covered next in this chapter. Overrides are simply ways that you can deviate from the vSwitch configuration on a granular level. An override example is shown in Figure 8.10.

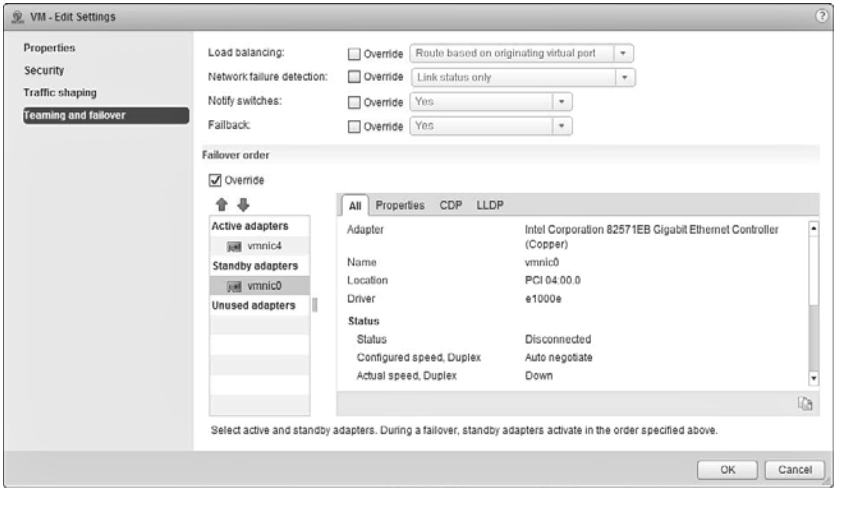


Figure 8.10 An example override on a failover order

For example, let's say that you have a pair of adapters being used as uplinks on a vSwitch. Within the vSwitch, you also have two VMkernel ports configured: one for management traffic and another for vMotion traffic. You can use overrides to set specific teaming and failover policies for each of those VMkernel ports. This allows you to separate management and vMotion traffic during steady-state operation, but still allow both to function in the event of a NIC Failure.

VMkernel Ports

The VMkernel ports, which are also referred to as "VMkernel networking interfaces" or even "virtual adapters" in various places, are special constructs used by the vSphere host to communicate with the outside world. You might recognize these ports due to their naming structure of vmk## with the "vmk" portion being a shorthand for VMkernel.

The goal of a VMkernel port is to provide some sort of Layer 2 or Layer 3 services to the vSphere host. Although a VM can talk to a VMkernel port, they do not consume them directly.

Port Properties and Services

VMkernel ports have important jobs to do and are vital for making sure that the vSphere host can be useful to the VMs. In fact, every VMkernel port can provide any combination of the following six services:

- vMotion traffic
- Fault tolerance (FT) logging
- Management traffic
- vSphere replication traffic
- iSCSI traffic
- NFS traffic

Figure 8.11 shows the administratively selectable services that can be enabled on a VMkernel port.

NOTE

While you can enable multiple services on a given VMkernel port, it is often preferable to split functions between multiple VMkernel ports. Fault tolerance (FT) logging, in particular, is strongly recommended to be segregated from any other function.

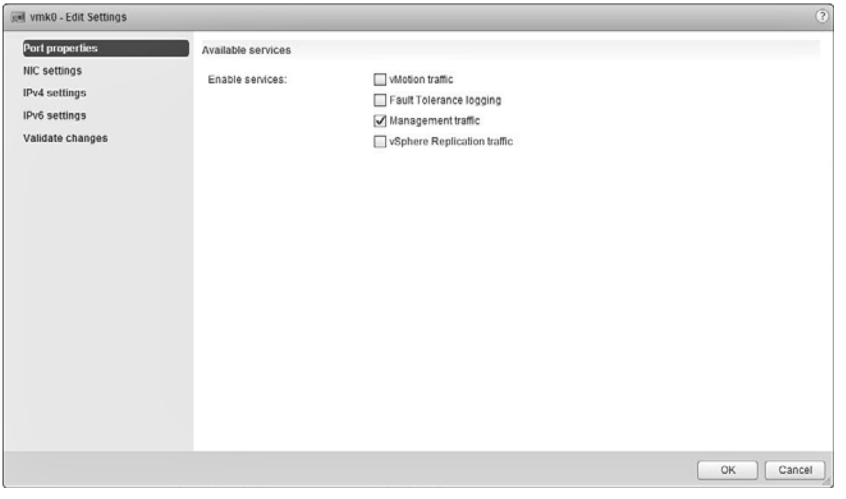


Figure 8.11 Services that can be enabled on a VMkernel port

You might notice that two of the services mentioned aren't shown as services that can be enabled: iSCSI traffic and NFS traffic. The reason is simple—there is no need to tell a VMkernel port that it can talk to iSCSI or NFS storage. All VMkernel ports can do this natively, and we typically just need to make sure that the IP address assigned to the appropriate VMkernel port is on the same subnet as the storage array.

NOTE

There are a lot of interesting design concepts around the use of VMkernel ports for iSCSI and NFS storage—feel free to skip ahead to Part 3 of this book if you want to learn more. For now, we'll just accept the fact that a VMkernel port doesn't need a service enabled to be useful for IP storage traffic.

IP Addresses

Every VMkernel port will have either an IPv4 or IPv6 address assigned, along with an MTU value. You have the choice of using a DHCP server for your IP address—which is not recommended for any serious production deployment—or assigning a static IP address.

Note that the default gateway and DNS server addresses are not definable by a VMkernel port. These values are input into the vSphere host directly. If the subnet you use for the

VMkernel port's IP address does not match the subnet of the destination IP address, the traffic will be routed over the VMkernel port that can reach the default gateway. Often, but not always, this is vmk0 (the default first VMkernel port created when you install ESXi).

> **TIP**
>
> Look carefully at the MAC address assigned to the vmk0 VMkernel port. Notice anything different about it when compared to other VMkernel ports? You should notice that vmk0 uses the real, burned-in address of the physical NIC instead of a randomly generated VMware MAC address. This MAC address is "seeded" at the time of the ESXi installation.

VM Port Groups

The final topic to touch on is VM port groups, which can be a bit of a struggle to understand at first. Let's imagine that you have a huge, unconfigured virtual switch with hundreds of ports on it. Chances are, you don't want all of the ports to be configured the same way—some of them will be used by your production VMs, others by your developers' VMs, and even more might be for the engineering VMs.

VM port groups are a way that we can create logical rules around the virtual ports that are made available to VMs. It's common to create a port group for each VLAN and network subnet that you want to present to your VMs. VM port groups do not provide vSphere services or require IP addresses—they are just ways to configure policy for a group of virtual ports on your vSwitch.

Figure 8.12 shows an example from our lab showing a vSwitch with a VM port group named "VM"—not very creative, sure, but it gets the point across. This is where we place our VMs, which are SQL, vCenter, and DC in this example. We've also disconnected one of the network adapters to show what that looks like.

You can also see our VMkernel port named "Management" just below the VM port group. It looks a lot like a VM port group, and that might be confusing at first. Don't worry, though—vCenter won't let you put a VM onto the "Management" VMkernel port.

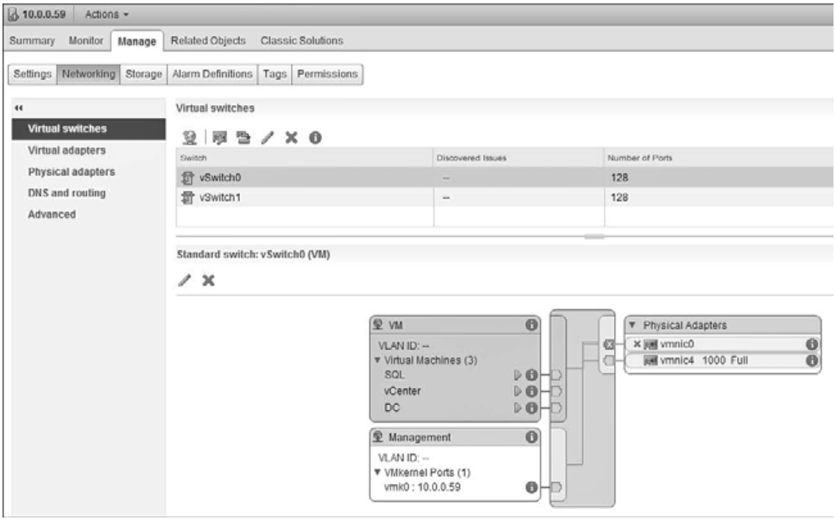


Figure 8.12 An example vSwitch with a VM port group named "VM"

Summary

We covered a lot of ground here, digging into every nook and cranny of the vSphere Standard Switch. You should now feel more knowledgeable about virtual switch configuration options, security settings, discovery settings, traffic-shaping policies, load-balancing methods, VMkernel ports, and port group configuration. In the next chapter, we take a close look at the options available with the vSphere Distributed Switch, highlighting the features that go above and beyond what is available with the Standard Switch.

This page intentionally left blank

This page intentionally left blank

Index

Symbols

A

B

C

D

G

H

I

J

L

M

N

O

P

Q

R

S

T

U

V