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(英文版)

Cisco LAN Switching

The most complete guide to Cisco Catalyst switch network design, operation, and configuration

[美] Kennedy Clark, CCSI, CCIE
Kevin Hamilton, CCSI 著

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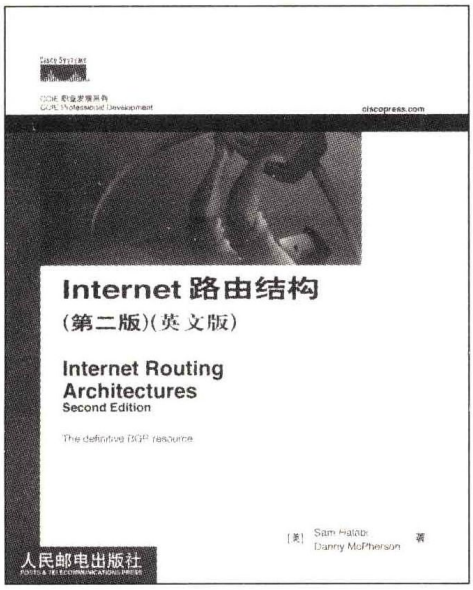

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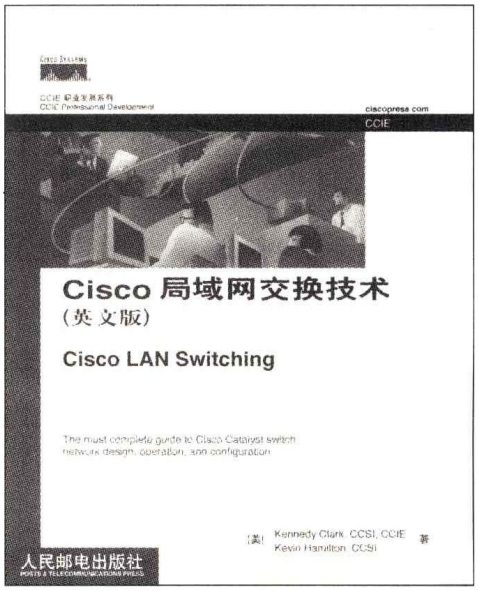

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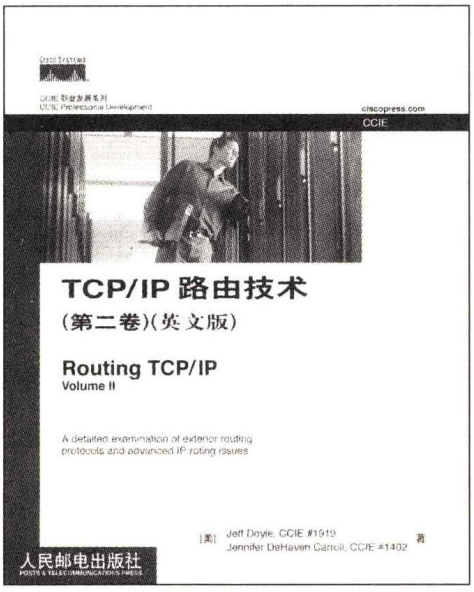

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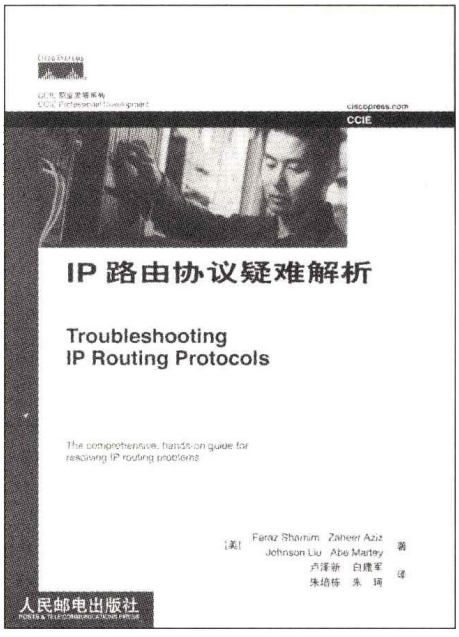

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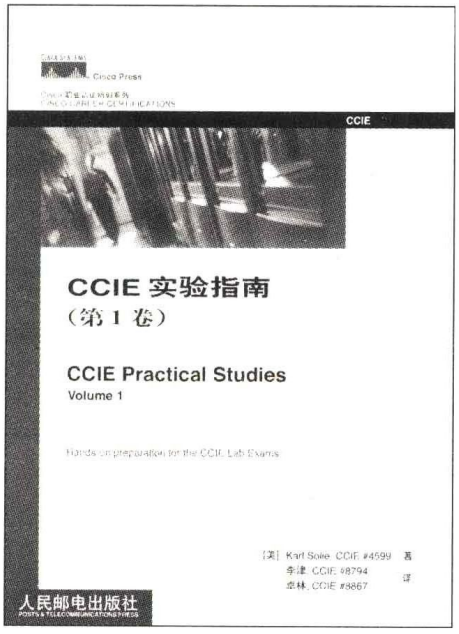

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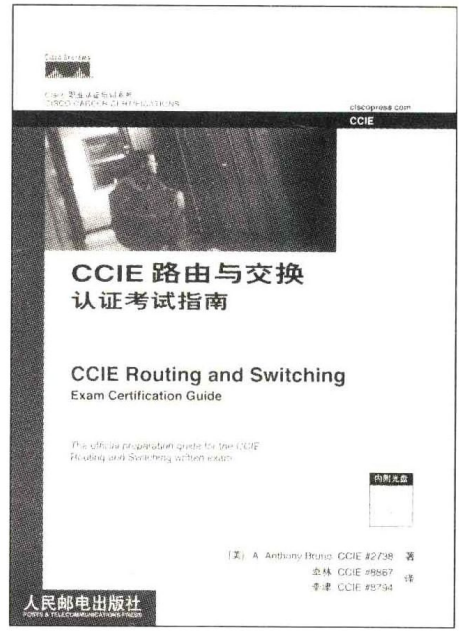

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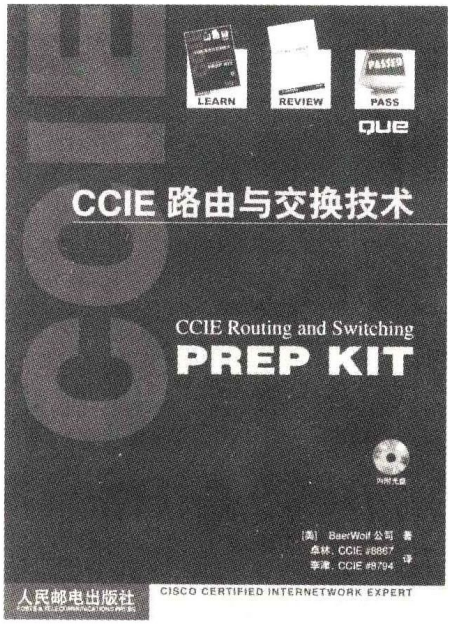

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内容提要

本书综合了在现代校园网中设计、利用和部署局域网交换设备及技术的最佳方法。全书分为六个部分，通过提供一系列已经证实的设计模型、实际实现解决方案和疑难解析策略，使我们了解了基本的交换概念范围之外的很多东西。第一部分讨论了重要的基础性问题，为后面的章节打下了基础。这一部分内容包括快速和吉比特以太网、路由选择和交换的比较、Layer 2 交换技术的类型、Catalyst 命令行环境以及 VLAN 等。第二部分详细讨论了已发布的生成树协议，其中包括常见问题、疑难解析以及像 PortFast、UplinkFast、BackboneFast 和 PVST+这样的改进技术。第三部分讨论了中继线连接中的关键问题以及用来在校园网中承载多个 VLAN 的链路。所有的章节都专门讨论 LANE 和 MPOA 的问题。第四部分提供了像 Layer 3 交换技术、VTP、CGMP 和 IGMP 这样的高级特性。第五部分则讲述了实际的校园网设计以及实现过程中遇到的问题，你可以从该部分中局域网交换技术专家的建议中获益。最后一部分讨论了 Catalyst 6000/6500 交换机系列中的问题，其中包括 Layer 3 交换技术中功能强大的 Native IOS Mode。

本书是网络工程师准备 CCIE 考试交换部分的权威指南。本书也适合要详细了解局域网交换技术的网络管理员、网络工程师、网络设计师以及网络项目经理阅读。

About the Authors

Kennedy Clark (CCIE #2175) is the Principal Technical Advisor for Mentor Technologies (formerly Chesapeake Computer Consultants, Inc.), a Cisco Training Partner. As a Cisco Certified Systems Instructor (CCSI), Kennedy was one of the original Catalyst instructors for Cisco. Having focused on Catalyst and ATM switching since 1996, he has taught a wide variety of switching classes. As a consultant, Kennedy has been involved in the design and implementation of many large, switched backbones. During the last 18 months, he has been helping develop Mentor's vLab product, an e-learning tool that allows people access to real-world network gear via their web browser. In this capacity, Kennedy invented and developed vLab Assessment, a product that allows vLab to provide detailed, dynamic feedback as a user moves through a vLab.

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Philip B. Bourgeois has been in the computer industry for fifteen years, spending seven years as a networking specialist with IBM and the past five years as a Senior Systems Engineer with Cisco Systems. Phil is experienced in the design and implementation of large IP and multiprotocol networks, encompassing complex wide area network designs and campus local area networks. Phil is a networking consultant to the largest commercial enterprises in the northeast area, including insurance, the health care industry, aerospace, pharmaceuticals, casino/gaming industry, state government agencies, and higher education. His current position is as a Consulting Systems Engineer with a specialty focus in high-speed LAN switching and ATM network design projects.

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Tom Nosella is Manager of Network Design Engineering for Cisco's Enterprise Line of Business. Tom and his team of network design engineers provide direction and expertise in enterprise network design for both Cisco's worldwide systems engineers and Cisco's enterprise customer base. Tom is a CCIE and has six years of experience in managing and designing large data networks for customers within the enterprise and service provider area. Tom joined Cisco Systems from Bell Canada where he led a team of network engineers providing outsourced network management services for large enterprise customers.

Dedications

To my wife, Debbie, for being the most supportive, understanding, patient, and loving partner a person could ever ask for. And, to God, for giving me the ability, gifts, and privilege to work in such an exciting and fulfilling career.

-Kennedy

To my wife, Emily, the true author in our family, who taught me the joy of communication through the printed page and who now has many romantic evenings due in appreciation for the ones neglected. And to my four boys, Jay, Scott, Alex and Caleb, who endured with exceeding patience the hours dad locked himself in a quiet room instead of playing ball and camping.

-Kevin

Acknowledgments

Kennedy Clark: An avid reader of all things nerdy, I have always taken acknowledgements and dedications fairly lightly. Having now been through the book-writing process myself, I can assure you that this will never be the case again. Writing a book (especially one on technology that is as fast-moving as switching) is an incredibly demanding process that warrants a huge number of "thank yous." In the brief space I have here, I would like to express appreciation to a small number of the people involved in this project. First, I would like to thank Kevin Hamilton, my co-author. Kevin was willing to jump into a project that had almost been left for dead because I was feeling completely overwhelmed by the staggering amount of work it involved. I would like to thank Radia Perlman for reading the e-mails and Spanning Tree chapters of an "unknown author." Also, the people at Cisco Press have been wonderful to work with (I would encourage other authors to check them out). Chris Cleveland and Brett Bartow deserve special mention. There are many people at Cisco to thank... Jon Crawfurd for giving a young NetWare guy a chance with router technology. Stuart Hamilton for taking this project under his wing. Merwyn Andrade for being the switching genius I someday hope to be. Tom Nosella for sticking with the project through its entirety. I owe many thanks to the people at Chesapeake Computer Consultants. I would especially like to thank Tim Brown for teaching me one of my first network courses and remaining a faithful friend and mentor. Also, Tom Van Meter for showing me the ropes with ATM. Finally, a very special thanks to my wife for her never-ending love and encouragement.

And, to God, for giving me the ability, gifts, and privilege to work in such an exciting and fulfilling career.

Kevin Hamilton: A project of this magnitude reflects the hard work of many individuals beyond myself. Most notably, Kennedy. He repeatedly amazes me with his ability to not only understand minute details for a vast array of subjects (many of which are Catalyst related), but to reiterate them without reference to written materials months and even years past the time when he is exposed to the point. His keen insights to networking and unique methods of communicating them consistently challenge me to greater professional depths. I, therefore, thank Kennedy for the opportunity to join him in this endeavor, and for the knowledge I gained as a result of sharing ink with him. I also must thank the staff and instructors at Chesapeake Computer Consultants for their continuous inspiration and support as we at times felt discouraged thinking we would never write the last page. And Tim Brown, who taught me that technology can be funny. And lastly, the staff at Cisco Press. Brett Bartow and Chris Cleveland must especially be commended for their direction and vision in this project. They worked hard at keeping us focused and motivated. I truly believe that without their guidance, we could never have produced this book on our own.

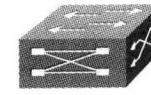
Icons Used in This Book

Throughout the book, you will see the following icons used for the varying types of switches:

ATM Switch

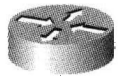
Catalyst 5000

Layer 3 (MLS) Routing Switch



Layer 3 (8500) Switching Router

In addition, you will see the usual battery of network device, peripheral, topology, and connection icons associated with Cisco Systems documentation. These icons are as follows:



Router

Bridge

Repeater

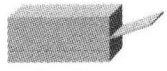
Hub

PBX/SWITCH

MAU

Modem

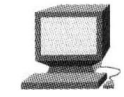
File Server



Printer

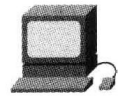
Phone

Terminal

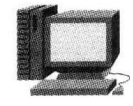


Workstation

PC

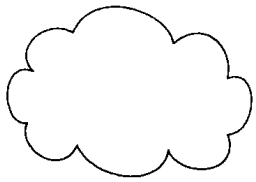


Sun Workstation

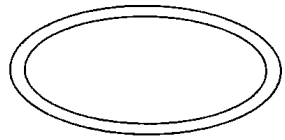


Macintosh

Telecommuter



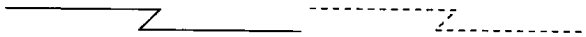
Network Cloud



FDDI Ring

Token Ring

Line: Ethernet



Line: Serial

Line: Circuit Switched

Foreword

With the advent of switching technology and specifically the enormously successful Catalyst Switching products from Cisco Systems, corporations all over the world are upgrading their infrastructures to enable their networks for high bandwidth applications. Although the original goal of most switched network design was primarily increased bandwidth, the networks of today require much more with the advent of mission critical applications and IP Voice emerging as mainstream networking requirements. It is therefore important not only to reap the bandwidth benefits of Catalyst switching but also learn sound network design principles leveraging all of the features in the Catalyst software suite.

One thing network designers have learned over the years is that things never get any easier when it comes to understanding and evaluating all of the available technologies that appear in standards bodies and are written about in trade magazines. We read about MPOA, LANE, Gigabit Ethernet, 802.1Q, 802.1p, Layer 3 switching, OSPF, BGP, VPN, MPLS, and many others. The key, however, to building and operating a successful network is understanding the basic fundamentals of the relevant technologies, knowing where and how to apply them most effectively in a network, and most importantly leveraging the successes of others to streamline the deployment of the network. Internetworking design is part art and part science mostly due to the fact that the applications that ride on top of the network have widely varying traffic characteristics. This represents another challenge when designing a network because you might well optimize it to perform for a certain application only to find that a few months later a brand new application places entirely differing demands on the network.

The science part of campus network design relies on a few basic principles. First, every user connects to a port on a switch and so wiring closets are provisioned with Catalyst switches such as the Catalyst 5000 family to connect end users either at 10 megabit Ethernet or increasingly 100 megabit Ethernet. The base level of switching capability here is called Layer 2 switching.

There are typically tens to hundreds of wiring closets that need to be connected somehow. Although there are many ways to do this, experience has taught us that a structured approach with some hierarchy is the best technique for a stable and easily expandable network. Wiring closets then are typically consolidated into a network layer called the distribution layer that is characterized by a combination of Layer 2 and Layer 3 switching.

If the network is large in size, there can still be a large number of distribution layer switches, and so in keeping with the structured methodology, another layer is used to network the distribution layer together. Often called the core of the network, a number of technologies can be used, typified by ATM, Gigabit Ethernet, and Layer 3 switching.

This probably sounds rather simple at this point, however as you can see from the thickness of this book, there is plenty of art (and a lot more science) toward making your design into a highly available, easy to manage, expandable, easy to troubleshoot network and preparing you with a solid foundation for new emerging applications.

This book not only covers the science part of networking in great detail in the early chapters, but more importantly deals with real-world experience in the implementation of networks using Catalyst products. The book's authors not only teach this material in training classes but also have to prove that they can make the network work at customer sites. This invaluable experience is captured throughout the book. Reading these tips carefully can save you countless hours of time experimenting on finding the best way to fine tune your particular network. In addition, as part of the CCIE Professional Development series of Cisco Press, you can use the experience gained from reading and understanding this book to prepare for one of the most sought after professional certifications in the industry.

Stuart Hamilton, CCIE #1282

Senior Manager, Enterprise Network Design

Cisco Systems Inc.

Introduction

Driven by a myriad of factors, LAN switching technology has literally taken the world by storm. The Internet, Web technology, new applications, and the convergence of voice, video, and data have all placed unprecedented levels of traffic on campus networks. In response, network engineers have had to look past traditional network solutions and rapidly embrace switching. Cisco, *the* router company, has jumped heavily into the LAN switching arena and quickly established a leadership position. The Catalyst series of switches has set a new standard for performance and features, not to mention sales.

Despite the popularity of campus switching equipment, it has been very difficult to obtain detailed and clear information on how it should be designed, utilized, and deployed. Although many books have been published in the last several years on routing technology, virtually no books have been published on LAN switching. The few that have been published are vague, out-of-date, and absent of real-world advice. Important topics such as the Spanning-Tree Protocol and Layer 3 switching have either been ignored or received inadequate coverage. Furthermore, most have contained virtually no useful information on the subject of campus design.

This book was written to change that. It has the most in-depth coverage of LAN switching technology in print to date. Not only does it have expansive coverage of foundational issues, but it is also full of practical suggestions. Proven design models, technologies, and strategies are thoroughly discussed and analyzed.

Both authors have drawn on their extensive experience with campus switching technology. As two of the first certified Catalyst instructors, they have first-hand knowledge of how to effectively communicate switching concepts. Through design and implementation experience, they have a detailed understanding of what works, as well as what doesn't work.

Objectives

Cisco LAN Switching is designed to help people move forward with their knowledge of the exciting field of campus switching. CCIE candidates will receive broad and comprehensive instruction on a wide variety of switching-related technologies. Other network professionals will also benefit from hard-to-find information on subjects such Layer 3 switching and campus design best practices.

Audience

Cisco LAN Switching should appeal to a wide variety of people working in the network field. It is designed for any network administrator, engineer, designer, or manager who requires a detailed knowledge of LAN switching technology.

Obviously, the book is designed to be an authoritative source for network engineers preparing for the switching portion of the CCIE exams and Cisco Career Certifications. *Cisco LAN Switching* is not a "quick fix" guide that helps you cram (such books are virtually worthless when it comes to taking the CCIE practical exams). Instead, it focuses extensively on theory and building practical knowledge. When allied with hands-on experience, this can be a potent combination.

However, this book is designed to go far beyond test preparation. It is designed to be both a tutorial and a reference tool for a wide range of network professionals, including the following:

- People with less switching experience will benefit extensively from the foundational material discussed in Part I. This material then transitions smoothly into the more advanced subject matter discussed in later chapters.
- Network professionals with a detailed understanding of routing but new to campus switching will find that *Cisco LAN Switching* can open up a whole new world of technology.

- Network engineers with extensive switching experience will find *Cisco LAN Switching* taking them farther into the field. For example, much of the Spanning-Tree Protocol information in Part II and the real-world design information in Part V has never been published before. The Catalyst 6000 material discussed in Part VI is also completely new.
- Network designers will benefit from the state-of-the-art coverage of campus design models and the detailed discussions of opposing design strategies.
- Engineers who have already obtained their CCIE will value *Cisco LAN Switching* as a reference tool and for design information.

Organization

The eighteen chapters and one appendix of this book fall into seven parts:

- **Part I: Foundational Issues**—This section takes you through technologies that underlie the material covered in the rest of the book. Important issues such as Fast Ethernet, Gigabit Ethernet, routing versus switching, the types of Layer 2 switching, the Catalyst command-line environment, and VLANs are discussed. Although advanced readers might want to skip some of this material, they are encouraged to at least skim the sections on Gigabit Ethernet and VLANs.
- **Part II: Spanning Tree**—The Spanning-Tree Protocol can make or break a campus network. Despite the ubiquitous deployment of this protocol, very little detailed information about its internals has been published. This section is designed to be the most comprehensive source available on this important protocol. It presents a detailed analysis of common problems and Spanning Tree troubleshooting. This chapter also discusses important enhancements such PortFast, UplinkFast, BackboneFast, and PVST+.
- **Part III: Trunking**—Part III examines the critical issue of trunk connections, the links used to carry multiple VLANs throughout a campus network. Chapter 8 begins with a detailed discussion of trunking concepts and covers Ethernet-based forms of trunking, ISL, and 802.1Q. Chapters 9 and 10 look at LAN Emulation (LANE) and MPOA (Multiprotocol over ATM), two forms of trunking that utilize Asynchronous Transfer Mode (ATM).
- **Part IV: Advanced Features**—This section begins with an in-depth discussion of the important topic of Layer 3 switching, a technology that has created a whole switching paradigm. Both MLS (routing switch) and hardware-based (switching router) routing are examined. The next two chapters examine the VLAN Trunking Protocol (VTP) and multicast-related topics such as Cisco Group Management Protocol (CGMP) and Internet Group Membership Protocol (IGMP) Snooping.
- **Part V: Real-World Campus Design and Implementation**—Part V focuses on real-world issues such as design, implementation, and troubleshooting. These chapters are oriented toward helping you benefit from the collective advice of many LAN switching experts.
- **Part VI: Catalyst 6000 Technology**—This section includes a chapter that analyzes the Catalyst 6000 and 6500 models. Focusing primarily on Layer 3 switching, it discusses the important "Native IOS Mode" of operation.
- **Part VII: Appendix**—The single appendix in this section provides answers and solutions to the Review Questions and Hands-On Labs from the book.

Features and Conventions

Where applicable, each chapter includes a variety of questions and exercises to further your knowledge of the material covered in that chapter. Many of the questions probe at the theoretical issues that indicate your mastery of the subject matter. Other questions and exercises provide an opportunity to build switching scenarios yourself. By utilizing extra equipment you might have available, you can build your own laboratory to explore campus switching. For those not fortunate enough to have racks of idle switching gear, the authors will be working with MentorLabs (http://www.mentorlabs.com) to provide value-added labs via the Internet.

Two conventions are used to draw your attention to sidebar, important, or useful information:

TIP Tips are used to highlight important points or useful shortcuts.

NOTE Notes are used for sidebar information related to the main text.

Various elements of Catalyst and Cisco router command syntax are presented in the course of each chapter. This book uses the same conventions as the Cisco documentation:

- Vertical bars (|) separate alternative, mutually exclusive, elements.
- Square brackets [] indicate optional elements.
- Braces { } indicate a required choice.
- Braces within square brackets [{ }] indicate a required choice within an optional element.
- **Boldface** indicates commands and keywords that are entered literally as shown.
- *Italics* indicate arguments for which you supply values.

Feedback

If you have questions, comments, or feedback, please contact the authors at the following e-mail addresses. By letting us know of any errors, we can fix them for the benefit of future generations. Moreover, being technical geeks in the true sense of the word, we are always up for a challenging technical discussion.

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Kevin Hamilton KHamilton@ccci.com

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