网络新技术系列丛书 影印版

Switched LANs

交换式局域网

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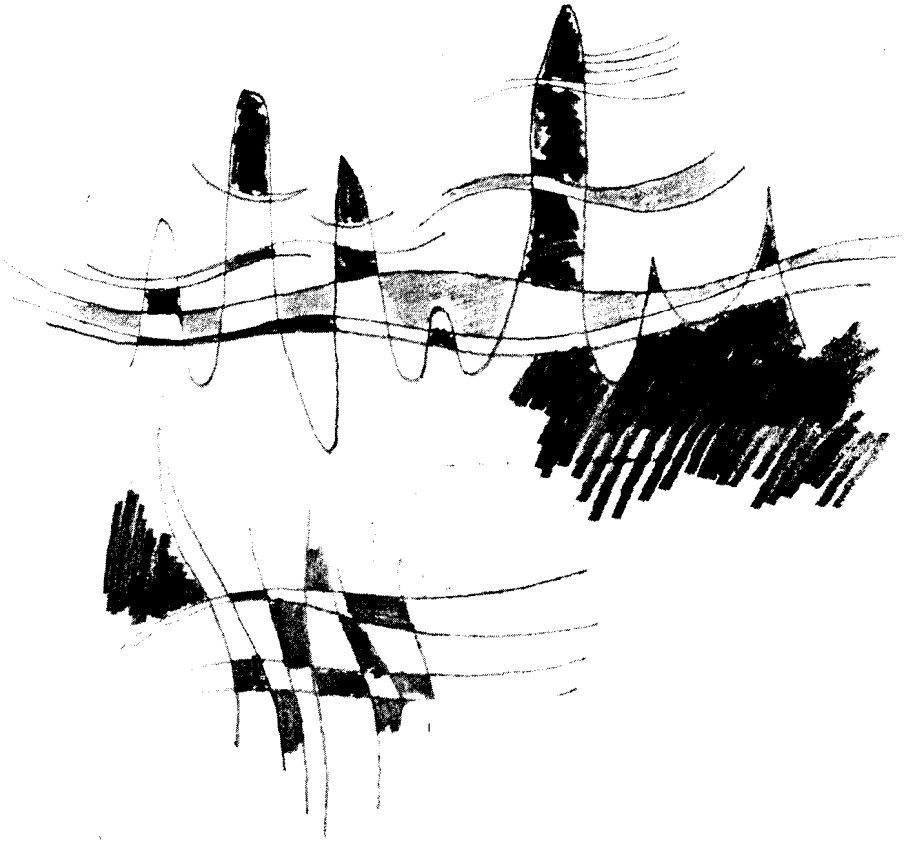

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Switched LANs—Implementation、operation、Maintenance/ John J. Roese

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出 版 前 言

21 世纪人类面对的将是一个网络化的新时代，网络化程度的高低将是衡量一个国家现代化水平和综合国力的重要标志。考虑到我国广大科技工作者面临着网络技术飞速发展的挑战，我们精选了一些反映网络技术最新发展的、且具有权威性的图书，组成“网络新技术系列丛书(影印版)”，奉献给广大读者。既表达对我国广大科技工作者的一种支持，也是我社为我国实施“科教兴国”的战略应尽的义务。

这套丛书包括：千兆以太网、移动 IP、虚拟局域网、交换式局域网、IP 组播技术、虚拟专用网、网络安全技术以及目录使能的网络等一系列先进技术。由于我们水平有限，希望各界专家和广大读者提出建议和要求，促使这套丛书出得更好。

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PREFACE

Over the past several years, the Local Area Network (LAN) has become easily the single most critical company resource. It has evolved from a simple basic system to an extremely high capacity communications lifeline of business. This evolution has been driven by the increased complexity and communications demands of the applications we use daily: e-mail, databases, video conferencing, and so forth. As the demands for bandwidth capacity increased, the traditional legacy equipment used to build the LAN became overburdened. Attempts were made to increase capacity, but it has become obvious that even enhancements to the existing hub and router technology will not be enough. The result of this analysis has led to a fundamental change in the implementation of local area networks. It has led to the implementation of switch-based LANs.

Switched LANs: Implementation, Operation, Maintenance provides system administrators, network planners, and network technicians with a comprehensive overview of the technology involved in implementing switched LANs. This book examines the major issues involved in successfully designing and building large-scale switched systems. Unlike typical networking texts that focus on one element of the network system—a protocol or IEEE standard, for instance—this book addresses the complete system. Basic physical operation of the switched LAN is discussed, but the real focus is on the practical issues involved in structuring your network and its protocols and services for long-term successful operation.

The primary reason I have developed this book is simple. There has been a shift in the basic building blocks of LANs away from hubs and routers and towards switch-based systems. While the shift is underway, if not complete, the mind set and knowledge base of the networking community are still focused on the assumptions made in legacy networks. As a technology trainer tasked with providing my students with the skills necessary to implement and support quality networks, I have come to realize that there is a very real requirement for reference material and guides to assist in the reeducation of those transitioning from router- and hub-based networks to switch-based networks. My goal is to take my experience with switched network operation and codify the major areas of concern in an organized reference. I have personally dealt with the issues involved in implementing switch-based systems and "flattening" networks (flattening a network is the process of removing

some or all of the router-based protocol segmentation). More importantly, my position has allowed me to experience and identify the potential implementation issues of switched networks and their solutions. Your network is not a laboratory; it is a critical element of your business. As such it is important to use proven implementation processes and have a complete understanding of them when deploying switches into your LAN. It is my sincere hope that *Switched LANs: Implementation, Operation, Maintenance* will provide that knowledge and assist you in successfully deploying and operating your switch-based network.

Acknowledgments

I would like to acknowledge and thank the many talented individuals who have assisted me in the process of creating this book—specifically, John Gorsky for his insight on network layer protocols; Mark Danckert, Robert Allende, and the many other innovators of this technology that I have worked with; and David Williams for his assistance in reviewing the network management chapters. This topic is entirely new in the networking industry, and without the assistance of my colleagues, who have led the way in switched LAN implementation, it would have been impossible to provide the comprehensive proven processes contained herein.

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INTRODUCTION

Designing, implementing, and operating networks is not simple. As the network becomes a more and more critical component of the business operations of almost every company, understanding its operation has become essential for system administrators. Unfortunately, with organizations' increased dependence on their networks come additional requirements for performance and reliability. Those additional demands have led to the implementation of far more complex networks. This book is devoted to a recent trend in network design: the Switched Local Area Network. In this book, you will find a complete reference for implementing a switched LAN. We will examine topics ranging from the definition and operation of LAN switches to proper methods of implementing several thousand node-switched networks. By examining the major aspects of switched LAN operation, implementation, and design a system administrator or network planner should have the necessary reference material to understand the compete switched LAN system.

The audience of this book is assumed to be familiar with the basic concepts of networking. If the reader is not familiar with the operation of core LAN technologies such as Ethernet or Internet protocols, the bibliography identifies appropriate reference material on the topics necessary for use of this book.

This book can be used in a number of ways, depending on readers' goals. If the goal is to understand switched LANs, it is recommended that the entire book be read in order. Reading this book in order will introduce the technology used in switched LANs and then provide design and implementation processes. The book examines the operation of specific protocols in switched LANs and concludes with additional assorted topics dealing with other miscellaneous features and tasks associated with building or operating a switched LAN. This sequence allows a reader who is unfamiliar with switched LANs to learn the basics before more complex protocol-related topics are introduced.

For current administrators of switched LANs, the book can be used as a reference guide. Most chapters are designed to stand alone and can be examined independently. If the reader is, for example, interested in the operation of a particular protocol over a switched LAN, or is planning the management strategy of a switched LAN, he or she should examine those specific chapters directly.

CONTENTS

CHAPTER 1

LAN Switching Defined

The word *switch* is possibly one of the most widely used terms in networking today. There are LAN switches, ATM switches, layer three switches, frame relay switches, phone switches, and many others. Unfortunately, the term *switch* has not been clearly defined in such a way as to fully define a type of device that accurately describes each of the technologies found in these various switches. Before a discussion of LAN switching can begin, an understandable definition of the term *switch* is necessary.

In order to freely use a definition of the term *switch* in describing the various types of switches, the definition must be suitably broad. It must also provide enough description of the components needed to be defined as a switch to be useful in comparison of various switching technologies. With these concerns in mind, the following definition of the term *switch* is proposed: *switch*—a device consisting of two components, input/output interfaces, and forwarding logic, capable of relaying data elements such as packets and cells.

This definition is illustrated in Figure 1.1.

This basic model of a switch provides a broad description of any type of switch. The two primary components are the forwarding logic and the input/output ports. The forwarding logic component describes the rules used by the switch technology to forward data units (packets and cells). These rules can be as simple as the transparent bridging mechanism used in LAN switches or as complex as those used by a multiprotocol router. The input/output ports are the physical or logical interfaces that connect to the communications network requiring data unit relaying. Examples include simple physical interfaces, such as LAN technologies including Ethernet, Token Ring, and FDDI. They can also include more abstract logical interfaces, such as emulated ATM LANs and fractionalized T1 interfaces. Even though this definition is very

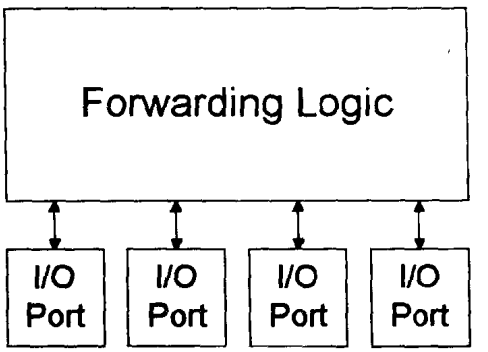


Figure 1.1
Basic switch model.

TABLE 1.1

Some Assorted Switching Technologies

Switch Type	Forwarding Logic	Input/Output Ports
ATM switch	Cell switching: virtual path and virtual circuit identifier remapping	OC-3/12/48 interfaces, T1/3, E1/3, TAXI, 25meg, fiber-optic and copper media
LAN switches	Transparent bridging (source address table)	Ethernet, Token Ring, FDDI, ATM ELANs, various WAN interfaces, spread spectrum, and other wireless technologies
Routers (layer three switches)	Protocol-based forwarding (network reachability)	Ethernet, Token Ring, FDDI, ATM ELANs, various WAN interfaces, spread spectrum, and other wireless technologies
Frame relay switches	DLCI forwarding	Various WAN interfaces

broad, it provides a framework in which different switching technologies can be evaluated. Table 1.1 describes the input/output ports and forwarding logic found in a variety of networking devices, all called switches.

Each of these technologies provides data relaying in its own way. Routers forward data based on protocol, while ATM switches care only about the VCI/VPI indicator in the header of the ATM cells. It is also true that many of these technologies share the same physical or logical input/output ports—for example, both LAN switches and routers can connect to Ethernet networks even though they do not share the same forwarding logic. Because they all meet the basic switch definition, all these technologies are correct in considering themselves switches.

The remainder of this chapter will focus primarily on one particular switch type: the LAN switch. This type of switch makes up the majority of local area networking switch ports. This technology, while not new, is allowing LANs to scale in size far beyond what was previously possible. We will first examine exactly what a LAN switch is and how it operates. We will then examine additional features, beyond the basic LAN switch definition, found in many LAN switches. The final section of this chapter will deal with the concept of layer three switching in terms of what it is and how it differs from LAN switching.

Basic Model of the LAN Switch

LAN switches are operationally equivalent to transparent bridges. That statement may offend some in the industry, but it is a fact. LAN switches forward data based on the mechanisms defined in the IEEE 801.1D specifications. This standard defines fundamental bridge operation, including elements such as source address tables, spanning tree algorithm, and transparent operation. Since both LAN switches and bridges adhere to the same architectural standard, they are operationally equivalent. It seems that in the networking industry, the term *bridge* became an offensive term, and all new bridges based on faster forwarding logic and having higher port density suddenly became known as switches, or LAN switches. This change in terminology caused a great deal of confusion in the industry, as system administrators and network planners struggled to understand what was different about these new switches and the "older" bridges. In reality, the only real noticeable difference was that these new switches were simply much larger, faster bridges. For the purposes of this book, the term *LAN switch* is used to describe a switch using the general forwarding rules defined in IEEE 801.1D.

Components

There are two major components to any switch. They are forwarding logic and input/output ports. Depending on the type of LAN switch, the input/output ports will vary to provide interfaces into many types of physical networks. Regardless of the physical input/output ports, the forwarding logic of all LAN switches will remain constant. It would be correct to state that it is the forwarding logic that defines the type of switch, rather than the physical interfaces.

Forwarding Logic Operation

The forwarding logic of a LAN switch is defined in IEEE 801.1D. The term used to describe the overall process is known as *transparent bridging*. This term refers to the fact that the forwarding logic should be transparent to the devices on the network. To understand how LAN switches can be technically invisible to the devices utilizing it, an understanding

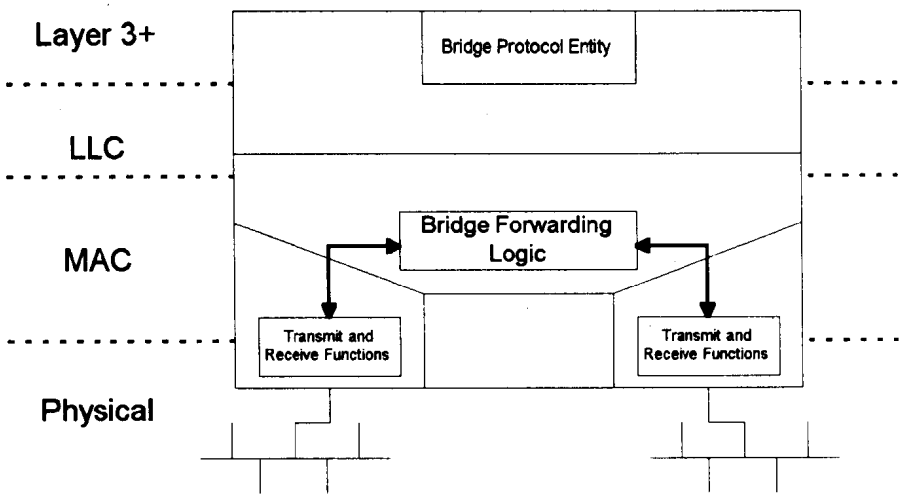


Figure 1.2
LAN switch (bridge) logical model.

of the basic forwarding logic of the switch is needed. Figure 1.2 illustrates the logical model of the LAN switch (or bridge).

In this model, the switch is defined against the first three layers of the OSI model. Its basic operation is at layer two in the relaying of MAC layer packets. It must also have layer one physical interfaces to connect to the LAN and WAN technologies it is located between and must have a higher-layer existence to facilitate its management operations, such as the spanning tree algorithm discussed later in this chapter. The forwarding logic component exists at layer two and is illustrated in Figure 1.3.

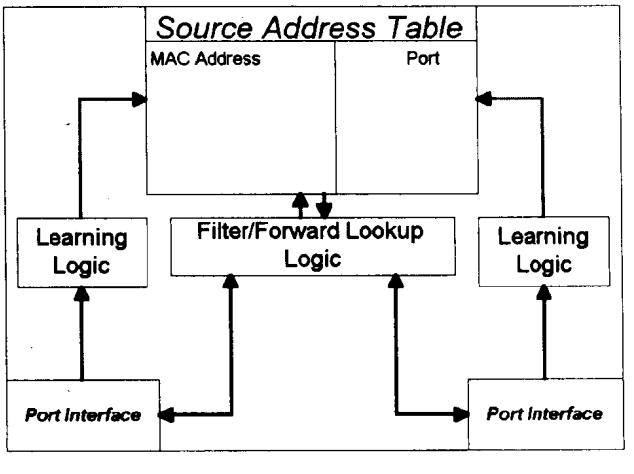


Figure 1.3
LAN switch (bridge) forwarding logic.

There are several key components in the forwarding logic of a LAN switch, as defined in the following list.

Forward/filter logic: This component decides the fate of all packets received by the switch. When packets are seen, the destination address is examined by the forwarding logic and compared to the entries in the source address table (SAT). If the destination address of the packet is found in the SAT and the location of the destination is on a port other than the one the packet was received on, the packet is forwarded out only that port. If the SAT shows that the destination is on the same port as the current packet, this packet is filtered by discarding it. If the SAT contains no information about the destination address, the packet is flooded out all ports. These processes are shown in Figure 1.4.

Learning logic: The source address table is a dynamic entity. When the switch is first initialized, it contains no information about MAC addresses on the LAN. The learning logic enables the switch to gather end-system MAC addresses and locations to populate the SAT. This learning is done on every packet received, regardless of whether the packet will be ultimately filtered or forwarded. On each received packet, the learning logic examines the source address and either adds a new entry to the source address table for that end-system MAC address and its corresponding port or updates the aging timer for an existing entry for that MAC address.

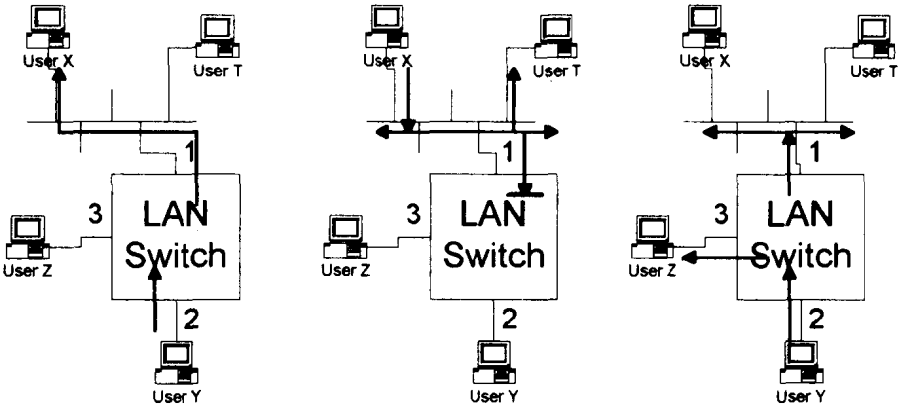
Port interface: This component is the logical interface into the physical port. At the port interface all layer one and two packet functions are performed. These include packet translations between technologies and interfacing into the MAC layer rules of the technologies.

Source address table: LAN switches are able to intelligently control packet flow based on this table. The format of the table consists of a list of MAC addresses of end systems and the associated port where they were last heard. The table is populated by the learning logic and is then utilized by the forward and filter logic to decide the fate of any received packet. Entries in this table have an associated age, which, when expired, allows the switch to discard that MAC address information. This table defines the capability of the switch. Since the table is limited in size, that size limits the particular LAN switch to deployments on LANs with a total MAC address count of less than or equal to the source address table (or SAT). This concept will be discussed in Chapter 3.

Figure 1.4 shows the three options the LAN switch forwarding logic uses to determine the action to be taken with any packet. If the destination is known and is on a different port than the received packet, forwarding takes place. If the destination is on the same port that received the packet, filtering takes place. Finally, if the destination is unknown, the packet is flooded out to all interfaces. This flooding mechanism allows LAN switches to deliver packets to devices that have not communicated yet and as such are not placed in the SAT by the learning logic.

The forwarding logic of the LAN switch allows for two very significant features: transparent operation and plug-and-play operation. The forwarding logic is transparent in its operation, based on the fact that the switch forwards layer two packets without modification to the MAC layer destination either deliberately or by flooding. Since the original packet is delivered, the destination has no indication that a switch has handled the packet. This feature is very desirable, as it allows the switch to exist in a LAN without any end-system configuration requirements. The second feature of LAN switch forwarding logic is its plug-and-play configuration. Since the learning logic of the forwarding logic will automatically populate the SAT as MAC addresses are seen, there is no configuration needed to add a LAN switch to the network. In fact,

Figure 1.4
Forwarding logic options.



Source Address Table

MAC Address	Port
X	1
Y	2
T	1