Table of Contents

Preface.

Introduction.

Part One Foundations of LAN Switches.

Chapter 1 Laying the Foundation.

Network Architecture.
Physical Layer.
Data Link Layer.
Network Layer.
Transport Layer.
Session Layer.
Presentation Layer.
Application Layer.

Layering Makes a Good Servant but a Bad Master.

Inside the Data Link Layer.

Modes of Operation.
Data Link Sublayering.
Logical Link Control.

Addressing.
Local and Global Uniqueness.
LAN Data Link Addresses.

Unicast and Multicast Addresses.

Globally Unique and Locally Unique MAC Addresses.

How LAN Addresses Are Assigned.

Written Address Conventions.

LAN Technology Review.

Ethernet.
Ethernet Medium Access Control.
Ethernet Physical Layer Options and Nomenclature.

Ethernet Frame Formats.

Bit-Ordering.

Token Ring.

Token Ring Medium Access Control.

Token Ring Physical Layer Options.
Chapter 2 Transparent Bridges.
Principles of Operation.
Unicast Operation.
Unknown and Multicast Destinations.
Generating the Address Table.
Address Table Aging.
Process Model of Table Operation.
Custom Filtering and Forwarding.
Multiple Bridge Topologies.
Transparent Bridge Architecture.
Maintaining the Link Invariants.
The Hard Invariants Are Hard Indeed.
Soft Invariants.
Implementing the Bridge Address Table.
Table Operations.
Search Algorithms.
Hash Tables.
Binary Search.
Content-Addressable Memories.
How Deep Is Your Table?
Chapter 3 Bridging Between Technologies.

Bridging the LAN Gap.
LAN Operational Mechanisms.
Frame Format Translation.
MAC-Specific Fields.
User Data Encapsulation.
Translating Versus Encapsulating Bridges.
Issues in Bridging Dissimilar LANs.
Maximum Transmission Unit (MTU).
Frame Check Protection.
Bit-Ordering.
Functional Groups Versus True Multicast Addressing.
LAN-Specific Features.
Thoughts on Bridging Dissimilar LANs.
Bridging Between Local and Wide Area Networks.
Applications of Remote Bridges.
Technologies for Remote Bridges.
Encapsulation.
Issues in Remote Bridges.
Error Rate.
LAN Bandwidth and Delay.
IEEE 802.1G—Not!

Chapter 4 Principles of LAN Switches.

A Switch Is a Bridge Is a Switch.
Switched LAN Concepts.
Separate Access Domains.
Segmentation and Microsegmentation.
Extended Distance Limitations.
Increased Aggregate Capacity.
Data Rate Flexibility.
MultiLayer Switching.
Layer 3 Switching.
A Router by Any Other Name Would Still Forward Packets.
Layer 3 Switch Operation.
Layer 4 Switching.
A Switch Is a Switch Is a Switch Except When...
Four Generations of Switch Integration.
Switch Configurations.
Bounded Systems.
Stackable Switches.
Stacking the Deck.
A Block in the Ointment.
United, We Are One.
Chassis Switches.
Switch Application Environments.
Desktop Level.
Workgroup Level.
Campus Level.
Enterprise Level.
The Needs Change with the Level.
Numbers of Ports.
Layer 2 Versus Layer 3 Switching (Bridging Versus Routing).
Table sizes.
Link Technologies.
Port Data Rates and Aggregate Capacity.
Media Support.

**Chapter 5 Loop Resolution.**
Diary of a Loopy LAN.
Getting Yourself in the Loop.
Getting out of the Loop.
The Spanning Tree Protocol.
History of the Spanning Tree Protocol.
Spanning Tree Protocol Operation.
Spanning Tree Protocol Concepts.
Calculating and Maintaining the Spanning Tree.
Bridge Protocol Data Units.
Port States.
Topology Changes.
Protocol Timers.
Issues in STP Implementation.
Queuing of BPDUs Relative to Data.
Save a Receive Buffer for Me!
Spanning Tree Protocol Performance.
Rapid Spanning Tree Protocol.
RSTP State of the Port Address.
Discarding.
Learning.
Forwarding.
Port Roles.
The Root Port.
The Designated Port.
The Alternate Port.
The Backup Port.
Forwarding State— Rapid Transition.
Edge Port.
Link Type.
BPDUs (Bip-A-Doo-Two).
BPDU —The Final Frontier ...er ... uh ... The New Format.
How It Is Now Handled.
Multiple Spanning Tree Protocol.
RSTP, MSTP, and STP (Can’t we all just get along?)
Loops in a Remotely Bridged (WAN) Catenet.
There’s More Than a One-Letter Difference.
Spanning Tree on aWAN.
Link Utilization.
Delay.
Using a Single Path for All Traffic.
Proprietary Loop Resolution Algorithms.
Routing Versus Bridging on the WAN.
An Example of Loop Resolution.
Behavior of a Spanning Tree Catenet.
Maintaining the Link Invariants.
Data Flow on the Spanning Tree.
Traffic Congregation at the Root.
Topology Changes and Disruption.
Configuring the Spanning Tree.

“We’ll All Be Planning That Root ’…”.

Assigning Link Costs.

Setting Protocol Timers.

Managing the Extent of the Catenet.

Up a Tree Without a Protocol?

Why Would Anyone Do This?

Interoperability.

What to Do, What to Do?

**Chapter 6 Source Routing.**

Overview of Source Routing Operation.

Eine Kleine Sourceroutinggeschichte.

Source Routing Concepts.

Nontransparency, or “Peek-a-Boo—I See You!”

Who’s the Boss?

Connection Orientation.

Be All That You Can Be (Without Joining the Army).

Even Token Rings Need to Get Out of the Loop Sometimes.

Ring and Bridge Numbering.

Route Discovery.

Maximum Transmission Unit Discovery.

Source-Routed Frames.

Differentiating Source-Routed and Non-Source-Routed Frames.

Non-Source-Routed Frames.

Source-Routed Frame Format.

Routing Control Fields.

Route Descriptors.

Source Routing Operation.

Route Discovery.

Route Discovery Algorithms.

Route Discovery Frames.

Route Selection.

Issues in Route Discovery.

Station Operation.

Architectural Model of Source Routing.

End Station Transmit Behavior.

End Station Receive Behavior.

Bridge Operation.

Bridge Behavior for Specifically Routed Frames.
Bridge Behavior for Explorer Frames (Both ARE and STE).
Interconnecting the Source-Routed and Transparently Bridged Universes.
Don't Bridge—Route!
The Source Routing-to-Transparent Bridge.
The Source Routing/Transparent Bridge.
IEEE Standards and Source Routing.
The Future of Source Routing.

**Part Two Advanced LAN Switch Concepts**

**Chapter 7 Full Duplex Operation.**

Why a MAC?.
Full Duplex Enablers.
Dedicated Media.
Dedicated LAN.
Full Duplex Ethernet.
"Ethernet Is CSMA/CD".
Full Duplex Ethernet Operating Environment.
Subset of Half Duplex Operation.
Transmitter Operation.
Receiver Operation.
Ethernet Minimum Frame Size Constraint.
Dedicated Token Ring.
Implications of Full Duplex Operation.
Eliminating the Link Length Restriction of Half Duplex Ethernet.
Increasing the Link Capacity.
Increasing Switch Load.
Full Duplex Application Environments.
Switch-to-Switch Connections.
Server and Router Connections.
Long-Distance Connections.

**Chapter 8 LAN and Switch Flow Control.**
The Need for Flow Control.
Default Switch Behavior.
The Effect of Frame Loss.
End-to-End Flow Control.
Cost-Performance Tradeoffs.
Controlling Flow in Half Duplex Networks.
Backpressure.
Aggressive Transmission Policies.
MAC Control.
Chapter 9 Link Aggregation

Link Aggregation Benefits.
Application of Link Aggregation.
Switch-to-Switch Connections.
Switch-to-Station (Server or Router) Connections.
Station-to-Station Connections.
Aggregate or Upgrade?
Issues in Link Aggregation.
Addressing.
Distributing Traffic Across an Aggregation.
Maintaining Link Invariants in an Aggregated Environment.
Separating Traffic Flows.
Conversation Determination Aids the Realization of Aggregation.
Mapping the Distribution Function to the Physical Link.
Conversations Above the Data Link Layer.
Summary of Distribution Functions.
Changing the Distribution.
Performance.
Technology Constraints (a.k.a. Link Aggravation).
Mixing LAN Technologies in a Single Aggregation.
Mixing Data Rates in a Single Aggregation.
Aggregation and Shared LANs.
Configuration Control.
IEEE 802.3ad Link Aggregation Standard.
Scope of the Standard.
Features and Benefits of the Standard.
Link Aggregation Architectural Model.
Binding Physical Ports to Aggregators.
Binding, Distribution, and Collection.
Addressing.
Marker Protocol Operation.
Link Aggregation Control Protocol.
LACP Concepts.
LACP Frame Format.
Split Up the Trunk.

Chapter 10 Multicast Pruning.
Multicast Usage.
Who Assigns Multicast Addresses?
Application Use of Multicast.
Implications of Default Behavior.
Trimming the (Spanning) Tree.
TheWeekend Networker’s Guide to Tree Pruning.
Receiver Declaration.
Registration of the Declaration.
Propagation of the Registration.
Source Pruning.
IEEE 802.1p.
GARP Multicast Registration Protocol.
Generic Attribute Registration Protocol.
GMRP Use of GARP.

Chapter 11 Virtual LANs: Applications and Concepts.
Applications of VLANs.
The Software Patch Panel.
LAN Security.
User Mobility.
Bandwidth Preservation.
VLAN Concepts.
Playing Tag on Your LAN.
Implicit Tags.
Explicit Tags.
VLAN Awareness and Tag Awareness.
VLAN Awareness.
What It Means to Be VLAN-Aware.
VLAN-Aware Switches.
VLAN-Aware End Stations.
He Looks Around, Around, He Sees VLANs in the Architecture, Spinning in Infinity...
Shared Media and VLAN Awareness.
Non–VLAN-Aware Switches and End Stations.
VLAN Association Rules (Mapping Frames to VLANs).
Port-Based VLAN Mapping.
MAC Address-Based VLAN Mapping.
Protocol-Based VLAN Mapping.
IP Subnet-Based VLAN Mapping.
A VLAN Phenomenon: The One-Armed Router.
Application-Based VLAN Mapping.
The Rules Follow the Application.
Frame Forwarding.

**Chapter 12 Virtual LANs: The IEEE Standard.**

Overview and Scope of the Standard.
Elements of the Standard.
Tag and Frame Formats.
VLAN Protocol Identifier.
Tag Control Information Field.
Embedded Routing Information Field.
Route Control Portion.
Route Descriptor Portion.
Tagged Ethernet Frames.
Flash! Ethernet MTU Increases by 4 Bytes!
Tagged Token Ring Frames.
Tagged FDDI Frames.
VLAN Tags on Other LAN Technologies.
A Word on Bit and Byte Order.
IEEE 802.1Q Switch Operation.
Ingress Process.
Acceptable Frame Filter.
Ingress Rules.
Ingress Filter.
Chapter 13 Priority Operation.

Why Priority?
LAN Priority Mechanisms.
Token Ring Priority Mechanisms.
FDDI Priority Mechanisms.
Ethernet Priority Mechanisms.
VLAN and Priority Tagging.
Getting into the Priority Business.
Priority Operation in Switches.
The Ordering Invariant—Redux.
IEEE 802.1p.
Switch Process Flow for Priority Operation.
Determining Frame Priority on Input.
Tag, You’re It!
LAN-Specific User Priority Indication.
Implicit Priority Determination, or "Whose Clues Do You Use?"
Priority Regeneration.
Mapping Input Priority to Class-of-Service.
Class of Service Versus Quality of Service.
How Many Queues Do You Chueues?
Default Priority Mappings.
Output Scheduling.
Scheduling Algorithms.
Indicating the Priority in Transmitted Frames.
Mapping User Priority to Access Priority at the Output Port.

**Chapter 14 LAN Security.**

Network Security Overview.
Hackers, Crackers, Viruses, and Those Confounded Worms.
Hac and Crac, the Ker Brothers.
Malware.
Physical Security.
Proactive Measures.
Virus Containment.
Firewalls.
End User Checks and Balances.
LAN Security.
Security Concerns at Layer 2.
Man in the Middle.
MAC Address Table Flooding.
DHCP Attacks.
Spanning Tree Attacks.
Private VLAN Attack.
VLAN Migration (Hopping) Attack.
ARP Spoofing Attack.
Wrap Up.

**Chapter 15 Switch Management.**

SNMP Concepts.
Manager/Agent Architecture.
Management Information Base.
Network Monitoring Tools.
Protocol Analysis in a Switched LAN.
Mirror, Mirror on the Switch, Which Is the Port That’s Got the Glitch?
Switch Mirroring.
Look Within Yourself for the Truth.
RMON Capabilities and MIBs.
Ethernet Statistics Group.
Ethernet History Group.
Chapter 16 Network Troubleshooting Strategies.

The Trouble with Troubleshooting.

Housekeeping.

Running the Network Baseline.

Proactive Troubleshooting.

Troubleshooting Tools.

Troubleshooting Utilities.

ping.

trace route.

netstat.

route.

ARP.

More Advanced Tools of the Trade.

Network Analyzers (or whatever they are calling them today).

Other Testing Equipment.

... and if all else fails.

A Systematic Approach.

Defining the Problem.

Sharing the Known.

Determining the Issue.

Developing a Solution.

Resolving and Taking Action!

Monitoring the Results.
The Final Step—Have a Beer!
Some Strategies for Layer 2 Troubleshooting.
Performing a Health Check.
Software, Hardware, and Configuration.
Issues Relating to Software.
Issues Relating to Hardware.
Issues Relating to Configuration.
Common Layer 2 Issues.
VLANS.
Duplex Mismatches.
Spanning Tree.
Wrap Up.

Chapter 17 Make the Switch!
Keeping House.
Housekeeping Functions.
Implementation and Performance (or, It's Tough to Find a Good Housekeeper).
Switch Data Receive Path Functions.
Port Interfaces (Receive).
Receive Flow Control.
Link Aggregation Collector.
Classification Engine.
Local Sinking of Reserved Multicast Addresses.
VLAN Ingress Rules.
Priority Assessment.
Do It Once and Save the Results.
Implementation of the Classification Engine.
VLAN Filters.
Lookup Engine.
Generating the Output Vector.
Maintaining the Filtering Database.
Lookup Implementation.
Switch Fabrics.
Shared Memory.
Shared Memory Fabric Operation.
Multicasting in a Shared Memory Architecture.
Buffer Organization.
Memory Bandwidth Limitations.
Increasing the Memory Bandwidth.