



Technology Training that Works

Practical Routers & Switches (including TCP/IP and Ethernet) for Engineers & Technicians

Contents

1	Introduction to communications	1
1.1	Data communications	1
1.2	Transmitters, receivers and communication channels	2
1.3	Types of communication channels	4
1.4	Communications channel properties	5
1.5	Data transmission modes	9
1.6	Encoding methods	13
1.7	Error detection	15
2	Networking fundamentals	17
2.1	Overview	17
2.2	Network communication	18
2.3	Types of networks	20
2.4	The open systems interconnection model	22
2.5	Interoperability and internetworking	30
2.6	Protocols and protocol standards	32
2.7	IEEE/ISO standards	33
2.8	Network topologies	36
2.9	Bus topology	37
2.10	Star topology	38
2.11	Ring topology	39
2.12	Media access methods	42
3	Ethernet networks	45
3.1	IEEE 802.3 CSMA/CD ("Ethernet")	45
3.2	Physical layer	46
3.3	Signaling methods	52
3.4	Medium access control	52
3.5	Frame transmission	53



Technology Training that Works

3.6	Frame reception	53
3.7	Collisions	54
3.8	MAC frame format	56
3.9	Difference between 802.3 and Ethernet	57
3.10	Reducing collisions	57
3.11	Ethernet design rules	58
4	Fast and gigabit Ethernet systems	61
4.1	Achieving higher speed	61
4.2	100BaseT (100BaseTX, T4, FX,T2)	62
4.3	Fast Ethernet design considerations	68
4.4	Gigabit Ethernet 1000BaseT	69
4.5	Gigabit Ethernet design considerations	74
5	Introduction to TCP/IP	77
5.1	The origins of TCP/IP	77
5.2	The ARPA model Vs The OSI model	78
5.3	The TCP/IP protocol suite Vs The ARPA model	78
6	Internet layer protocols	81
6.1	Overview	82
6.2	Internet Protocol version 4 (IPv4)	82
6.3	Internet Protocol version 6 (IPv6/ IPng)	97
6.4	Address Resolution Protocol (ARP)	106
6.5	Reverse Address Resolution Protocol (RARP)	110
6.6	Internet Control Message Protocol (ICMP)	111
6.7	Routing protocols	118
6.8	Interior gateway protocols	122
6.9	Exterior Gateway Protocols (EGP's)	124
7	Host to Host (transport) layer protocols	127
7.1	TCP (Transmission Control Protocol)	128
7.2	UDP (User Datagram Protocol)	136



Technology Training that Works

8	Application layer protocols	139
8.1	Introduction	139
8.2	File Transfer Protocol (FTP)	140
8.3	Trivial File Transfer Protocol (TFTP)	143
8.4	TELNET (Telecommunications Network)	146
8.5	RLOGIN (Remote Login)	149
8.6	NFS (Network File System)	149
8.7	DNS (Domain Name System)	150
8.8	WINS	155
8.9	SNMP (Simple Network Management Protocol)	157
8.10	SMTP (Simple Mail Transfer Protocol)	161
8.11	POP (Post Office Protocol)	162
8.12	BOOTP (Bootstrap Protocol)	163
8.13	DHCP (Dynamic Host Configuration Protocol)	164
9	TCP/IP utilities	169
9.1	Introduction	169
9.2	PING (Packet Internet Groper)	169
9.3	ARP	173
9.4	NETSTAT	174
9.5	NBTSTAT	174
9.6	IPCONFIG	175
9.7	WINIPCFG	176
9.8	TRACE RouTe	177
9.9	ROUTE	179
9.10	The HOSTS file	180
10	LAN system components	181
10.1	Introduction	181
10.2	Repeaters	182
10.3	Media converters	183
10.4	Bridges	184
10.5	Hubs	187
10.6	Switches	189
10.7	Routers	194
10.8	Gateways	195



Technology Training that Works

10.9	Print servers	195
10.10	Terminal servers	196
10.11	Thin servers	196
10.12	Remote access servers	197
10.13	Network timeservers	198
11	Internet access	199
11.1	Connecting a single host to the Internet	199
11.2	Connecting remote hosts to corporate LAN	201
11.3	Connecting multiple hosts to the Internet	201
12	Troubleshooting TCP/IP	205
12.1	Maintenance and troubleshooting of real TCP/IP networks	205
12.2	Network troubleshooting	206
12.3	Troubleshooting with TCP/IP Utilities	207
13	Virtual LAN	211
13.1	Need for VLAN	211
13.2	Benefits of a VLAN	214
13.3	VLAN restrictions	215
13.4	Basic operation of a VLAN	216
13.5	VLAN implementation	216
13.6	Combination of definitions	220
13.7	Method of connections	220
13.8	Filtering table	222
13.9	Tagging	222
13.10	Conclusion	223
14	Virtual Private Networks	225
14.1	The Internet and the new communication paradigm	226
14.2	What is a VPN?	227
14.3	Types of VPN	227
14.4	Requirements for designing a VPN system	228
14.5	Defining of policy	229
14.6	Functional requirements	229
14.7	Security	236
14.8	Conclusion	247



Technology Training that Works

15	Routing basics and RIP	249
15.1	Routing basics	249
15.2	Routing Information Protocol (RIP)	256
16	Interior Gateway Routing Protocol (IGRP)	263
16.1	Origins	263
16.2	IGRP metrics	265
16.3	Specifications	267
16.4	Operation of IGRP	269
16.5	Dealing with topology changes	269
16.6	Limitations of IGRP	272
16.7	Multipath Routing	272
17	Enhanced IGRP (EIRGP)	273
17.1	Introduction	273
17.2	Enhanced IGRP capabilities and attributes	273
17.3	Underlying processes and technologies	274
17.4	Routing concepts	275
17.5	Enhanced IGRP packet types	276
17.6	Summary	277
18	Open Shortest Path First	279
18.1	Background	279
18.2	Routing hierarchy	280
18.3	SPF algorithm	281
18.4	Packet format	282
18.5	Additional OSPF features	283
19	Advanced router considerations	285
19.1	Background	285
19.2	MPLS and tag switching	286
19.3	MPLS operations	287
19.4	MPLS/Tag-switching architecture	288



Technology Training that Works

19.5	Hierarchical routing	289
19.6	Multicast routing	290
19.7	Label switching with ATM	290
19.8	Quality of service and traffic engineering	291
<hr/> Appendix A: Glossary		293
<hr/> Appendix B: Port number allocation		311
<hr/> Appendix C: Security considerations		313
<hr/> Appendix D: Firewalls		331
<hr/> Appendix E: Border Gateway Protocol		347
<hr/> Appendix F: CISCO Devices		355
<hr/> Appendix G: Routers – Practical Exercise		473