

pfSense: The Definitive Guide

The Definitive Guide to the pfSense Open Source Firewall and Router Distribution

Contents

| | | |
|----------|--|-----------|
| 1 | Introduction | 1 |
| 1.1 | What does pfSense stand for/mean? | 1 |
| 1.2 | Why FreeBSD? | 1 |
| 1.3 | Common Deployments | 2 |
| 1.4 | Versions | 5 |
| 1.5 | Platforms | 6 |
| 1.6 | Networking Concepts | 7 |
| 1.7 | Interface Naming Terminology | 13 |
| 1.8 | Finding Information and Getting Help | 14 |
| 2 | Hardware | 15 |
| 2.1 | Hardware Compatibility | 15 |
| 2.2 | Minimum Hardware Requirements | 16 |
| 2.3 | Hardware Selection | 17 |
| 2.4 | Hardware Sizing Guidance | 18 |
| 3 | Installation Guide | 23 |
| 3.1 | Downloading pfSense | 23 |
| 3.2 | Full Installation | 24 |
| 3.3 | Embedded Installation | 28 |
| 3.4 | Alternate Installation Techniques | 33 |
| 3.5 | Installation Troubleshooting | 35 |
| 3.6 | Recovery Installation | 38 |
| 3.7 | Upgrading an Existing Installation | 39 |
| 4 | Configuration | 43 |
| 4.1 | Connecting to the WebGUI | 43 |
| 4.2 | Setup Wizard | 44 |
| 4.3 | Interface Configuration | 52 |
| 4.4 | General Configuration Options | 53 |
| 4.5 | Advanced Configuration Options | 54 |
| 4.6 | Console Menu Basics | 59 |
| 4.7 | Time Synchronization | 62 |
| 4.8 | Troubleshooting | 65 |
| 4.9 | pfSense's XML Configuration File | 68 |
| 4.10 | What to do if you get locked out of the WebGUI | 68 |
| 4.11 | Final Configuration Thoughts | 72 |

| | |
|--|------------|
| 5 Backup and Recovery | 73 |
| 5.1 Backup Strategies | 73 |
| 5.2 Making Backups in the WebGUI | 74 |
| 5.3 Using the AutoConfigBackup Package | 74 |
| 5.4 Alternate Remote Backup Techniques | 77 |
| 5.5 Restoring from Backups | 78 |
| 5.6 Backup Files and Directories with the Backup Package | 80 |
| 5.7 Caveats and Gotchas | 81 |
| 6 Firewall | 83 |
| 6.1 Firewalling Fundamentals | 83 |
| 6.2 Introduction to the Firewall Rules screen | 87 |
| 6.3 Aliases | 90 |
| 6.4 Firewall Rule Best Practices | 95 |
| 6.5 Rule Methodology | 98 |
| 6.6 Configuring firewall rules | 104 |
| 6.7 Methods of Using Additional Public IPs | 107 |
| 6.8 Virtual IPs | 108 |
| 6.9 Time Based Rules | 109 |
| 6.10 Viewing the Firewall Logs | 110 |
| 6.11 Troubleshooting Firewall Rules | 113 |
| 7 Network Address Translation | 115 |
| 7.1 Default NAT Configuration | 115 |
| 7.2 Port Forwards | 116 |
| 7.3 1:1 NAT | 119 |
| 7.4 Ordering of NAT and Firewall Processing | 123 |
| 7.5 NAT Reflection | 127 |
| 7.6 Outbound NAT | 130 |
| 7.7 Choosing a NAT Configuration | 131 |
| 7.8 NAT and Protocol Compatibility | 132 |
| 7.9 Troubleshooting | 136 |
| 8 Routing | 139 |
| 8.1 Static Routes | 139 |
| 8.2 Routing Public IPs | 141 |
| 8.3 Routing Protocols | 144 |
| 8.4 Route Troubleshooting | 145 |
| 9 Bridging | 151 |
| 9.1 Bridging and firewalling | 151 |
| 9.2 Bridging two internal networks | 152 |
| 9.3 Bridging OPT to WAN | 153 |
| 9.4 Bridging interoperability | 153 |
| 10 Virtual LANs (VLANs) | 159 |
| 10.1 Requirements | 159 |
| 10.2 Terminology | 160 |

| | | |
|-----------|--|------------|
| 10.3 | VLANs and Security | 161 |
| 10.4 | pfSense Configuration | 162 |
| 10.5 | Switch Configuration | 167 |
| 11 | Multiple WAN Connections | 179 |
| 11.1 | Choosing your Internet Connectivity | 179 |
| 11.2 | Multi-WAN Terminology and Concepts | 180 |
| 11.3 | Multi-WAN Caveats and Considerations | 182 |
| 11.4 | Interface and DNS Configuration | 184 |
| 11.5 | Multi-WAN Special Cases | 186 |
| 11.6 | Multi-WAN and NAT | 186 |
| 11.7 | Load Balancing | 187 |
| 11.8 | Failover | 189 |
| 11.9 | Verifying Functionality | 190 |
| 11.10 | Policy Routing, Load Balancing and Failover Strategies | 192 |
| 11.11 | Multi-WAN on a Stick | 194 |
| 11.12 | Troubleshooting | 195 |
| 12 | Virtual Private Networks | 197 |
| 12.1 | Common deployments | 197 |
| 12.2 | Choosing a VPN solution for your environment | 199 |
| 13 | IPsec | 203 |
| 13.1 | IPsec Terminology | 203 |
| 13.2 | Choosing configuration options | 204 |
| 13.3 | IPsec and firewall rules | 206 |
| 13.4 | Site to Site | 206 |
| 13.5 | Mobile IPsec | 214 |
| 13.6 | IPsec Troubleshooting | 234 |
| 13.7 | Configuring Third Party IPsec Devices | 242 |
| 14 | PPTP VPN | 247 |
| 14.1 | PPTP Security Warning | 247 |
| 14.2 | PPTP and Firewall Rules | 247 |
| 14.3 | PPTP and Multi-WAN | 247 |
| 14.4 | PPTP Limitations | 248 |
| 14.5 | PPTP Server Configuration | 248 |
| 14.6 | PPTP Client Configuration | 252 |
| 14.7 | Increasing the Simultaneous User Limit | 271 |
| 14.8 | PPTP Redirection | 272 |
| 14.9 | PPTP Troubleshooting | 272 |
| 14.10 | PPTP Routing Tricks | 273 |
| 14.11 | PPTP Logs | 274 |
| 15 | OpenVPN | 275 |
| 15.1 | Basic Introduction to X.509 Public Key Infrastructure | 275 |
| 15.2 | Generating OpenVPN Keys and Certificates | 276 |
| 15.3 | OpenVPN Configuration Options | 283 |

| | | |
|-----------|---|------------|
| 15.4 | Remote Access Configuration | 287 |
| 15.5 | Site to Site Example Configuration | 292 |
| 15.6 | Filtering and NAT with OpenVPN Connections | 294 |
| 15.7 | OpenVPN and Multi-WAN | 295 |
| 15.8 | OpenVPN and CARP | 297 |
| 15.9 | Bridged OpenVPN Connections | 297 |
| 15.10 | Custom configuration options | 297 |
| 15.11 | Troubleshooting OpenVPN | 299 |
| 16 | Traffic Shaper | 301 |
| 16.1 | Traffic Shaping Basics | 301 |
| 16.2 | What the Traffic Shaper can do for you | 302 |
| 16.3 | Hardware Limitations | 303 |
| 16.4 | Limitations of the Traffic Shaper implementation in 1.2.x | 303 |
| 16.5 | Configuring the Traffic Shaper With the Wizard | 304 |
| 16.6 | Monitoring the Queues | 308 |
| 16.7 | Advanced Customization | 309 |
| 16.8 | Troubleshooting Shaper Issues | 314 |
| 17 | Server Load Balancing | 317 |
| 17.1 | Explanation of Configuration Options | 317 |
| 17.2 | Web Server Load Balancing Example Configuration | 319 |
| 17.3 | Troubleshooting Server Load Balancing | 326 |
| 18 | Wireless | 329 |
| 18.1 | Recommended Wireless Hardware | 329 |
| 18.2 | Wireless WAN | 330 |
| 18.3 | Bridging and wireless | 333 |
| 18.4 | Using an External Access Point | 334 |
| 18.5 | pfSense as an Access Point | 336 |
| 18.6 | Additional protection for your wireless network | 339 |
| 18.7 | Configuring a Secure Wireless Hotspot | 341 |
| 18.8 | Troubleshooting Wireless Connections | 343 |
| 19 | Captive Portal | 345 |
| 19.1 | Limitations | 345 |
| 19.2 | Portal Configuration Without Authentication | 346 |
| 19.3 | Portal Configuration Using Local Authentication | 347 |
| 19.4 | Portal Configuration Using RADIUS Authentication | 347 |
| 19.5 | Configuration Options | 347 |
| 19.6 | Troubleshooting Captive Portal | 350 |
| 20 | Firewall Redundancy / High Availability | 351 |
| 20.1 | CARP Overview | 351 |
| 20.2 | pfsync Overview | 352 |
| 20.3 | pfSense XML-RPC Sync Overview | 352 |
| 20.4 | Example Redundant Configuration | 352 |
| 20.5 | Multi-WAN with CARP | 362 |

| | | |
|-----------|---|------------|
| 20.6 | Verifying Failover Functionality | 365 |
| 20.7 | Providing Redundancy Without NAT | 366 |
| 20.8 | Layer 2 Redundancy | 368 |
| 20.9 | CARP with Bridging | 370 |
| 20.10 | CARP Troubleshooting | 371 |
| 21 | Virtualization | 375 |
| 21.1 | Security Risks with Virtualization | 375 |
| 21.2 | Supported Hypervisors | 375 |
| 21.3 | VMware and Networking | 376 |
| 21.4 | Common Deployments | 376 |
| 22 | Services | 377 |
| 22.1 | DHCP Server | 377 |
| 22.2 | DHCP Relay | 382 |
| 22.3 | DNS Forwarder | 382 |
| 22.4 | Dynamic DNS | 384 |
| 22.5 | SNMP | 386 |
| 22.6 | UPnP | 388 |
| 22.7 | OpenNTPD | 391 |
| 22.8 | Wake on LAN | 391 |
| 22.9 | PPPoE Server | 393 |
| 23 | System Monitoring | 395 |
| 23.1 | System Logs | 395 |
| 23.2 | System Status | 398 |
| 23.3 | Interface Status | 398 |
| 23.4 | Service Status | 400 |
| 23.5 | RRD Graphs | 400 |
| 23.6 | Firewall States | 403 |
| 23.7 | Traffic Graphs | 403 |
| 24 | Packages | 405 |
| 24.1 | Introduction to Packages | 405 |
| 24.2 | Installing Packages | 406 |
| 24.3 | Reinstalling and Updating Packages | 407 |
| 24.4 | Uninstalling Packages | 407 |
| 24.5 | Developing Packages | 408 |
| 25 | Third Party Software and pfSense | 409 |
| 25.1 | RADIUS Authentication with Windows Server | 409 |
| 25.2 | Free Content Filtering with OpenDNS | 414 |
| 25.3 | Syslog Server on Windows with Kiwi Syslog | 423 |
| 25.4 | Using Software from FreeBSD's Ports System (Packages) | 423 |
| 26 | Packet Capturing and Sniffing | 427 |
| 26.1 | Selecting the Proper Interface | 427 |
| 26.2 | Packet Captures from the WebGUI | 428 |

| | | |
|----------|--|------------|
| 26.3 | Using tcpdump from the command line | 429 |
| 26.4 | Using Wireshark with pfSense | 438 |
| 26.5 | Plain Text Protocol Debugging with tcpflow | 441 |
| 26.6 | Additional References | 441 |
| A | Menu Guide | 443 |

List of Figures

| | | |
|------|---|-----|
| 1.1 | Subnet Mask Converter | 11 |
| 1.2 | Network/Node Calculator | 11 |
| 1.3 | Network/Node Calculator | 12 |
| 4.1 | Setup Wizard Starting Screen | 44 |
| 4.2 | General Information Screen | 45 |
| 4.3 | NTP and Time Zone Setup Screen | 45 |
| 4.4 | WAN Configuration | 46 |
| 4.5 | General WAN Configuration | 47 |
| 4.6 | Static IP Settings | 47 |
| 4.7 | DHCP Hostname Setting | 47 |
| 4.8 | PPPoE Configuration | 48 |
| 4.9 | PPTP WAN Configuration | 49 |
| 4.10 | Built-in Ingress Filtering Options | 49 |
| 4.11 | LAN Configuration | 50 |
| 4.12 | Change Administrative Password | 51 |
| 4.13 | Reload pfSense WebGUI | 51 |
| 4.14 | Setting up a port 80 SSH Tunnel in PuTTY | 71 |
| 5.1 | WebGUI Backup | 74 |
| 5.2 | WebGUI Restore | 78 |
| 5.3 | Configuration History | 79 |
| 6.1 | Increased state table size to 50,000 | 84 |
| 6.2 | Default WAN rules | 88 |
| 6.3 | Default LAN rules | 88 |
| 6.4 | Add LAN rule options | 89 |
| 6.5 | Example hosts alias | 91 |
| 6.6 | Example network alias | 92 |
| 6.7 | Example ports alias | 93 |
| 6.8 | Autocompletion of hosts alias | 94 |
| 6.9 | Autocompletion of ports alias | 94 |
| 6.10 | Example Rule Using Aliases | 94 |
| 6.11 | Hovering shows contents | 95 |
| 6.12 | Hovering shows contents | 95 |
| 6.13 | Firewall Rule to Prevent Logging Broadcasts | 97 |
| 6.14 | Alias for management ports | 99 |
| 6.15 | Alias for management hosts | 100 |

| | | |
|-------|---|-----|
| 6.16 | Alias list | 100 |
| 6.17 | Example restricted management LAN rules | 101 |
| 6.18 | Restricted management LAN rules — alternate example | 101 |
| 6.19 | Anti-lockout rule disabled | 102 |
| 6.20 | Testing name resolution for bogon updates | 103 |
| 6.21 | Example Log Entries viewed from the WebGUI | 110 |
| 7.1 | Add Port Forward | 117 |
| 7.2 | Port Forward Example | 118 |
| 7.3 | Port Forward List | 119 |
| 7.4 | Port Forward Firewall Rule | 119 |
| 7.5 | 1:1 NAT Edit screen | 120 |
| 7.6 | 1:1 NAT Example - Single inside and outside IP | 121 |
| 7.7 | 1:1 NAT Entry | 122 |
| 7.8 | 1:1 NAT entry for /30 CIDR range | 123 |
| 7.9 | Ordering of NAT and Firewall Processing | 124 |
| 7.10 | LAN to WAN Processing | 125 |
| 7.11 | WAN to LAN Processing | 126 |
| 7.12 | Firewall Rule for Port Forward to LAN Host | 127 |
| 7.13 | Enable NAT Reflection | 128 |
| 7.14 | Add DNS Forwarder Override | 128 |
| 7.15 | Add DNS Forwarder Override for example.com | 129 |
| 7.16 | DNS Forwarder Override for www.example.com | 129 |
| 8.1 | Static Route | 139 |
| 8.2 | Static route configuration | 140 |
| 8.3 | Asymmetric routing | 140 |
| 8.4 | WAN IP and gateway configuration | 142 |
| 8.5 | Routing OPT1 configuration | 143 |
| 8.6 | Outbound NAT configuration | 143 |
| 8.7 | OPT1 firewall rules | 144 |
| 8.8 | WAN firewall rules | 144 |
| 8.9 | Route Display | 145 |
| 9.1 | Firewall Rule to Allow DHCP | 152 |
| 10.1 | Interfaces: Assign | 165 |
| 10.2 | VLAN List | 165 |
| 10.3 | Edit VLAN | 166 |
| 10.4 | VLAN List | 166 |
| 10.5 | Interface list with VLANs | 167 |
| 10.6 | VLAN Group Setting | 171 |
| 10.7 | Enable 802.1Q VLANs | 171 |
| 10.8 | Confirm change to 802.1Q VLAN | 171 |
| 10.9 | Default 802.1Q configuration | 172 |
| 10.10 | Add new VLAN | 172 |
| 10.11 | Add VLAN 10 | 173 |
| 10.12 | Add VLAN 20 | 173 |

| | | |
|-------|---|-----|
| 10.13 | Toggle VLAN membership | 174 |
| 10.14 | Configure VLAN 10 membership | 174 |
| 10.15 | Configure VLAN 20 membership | 175 |
| 10.16 | PVID Setting | 175 |
| 10.17 | Default PVID Configuration | 176 |
| 10.18 | VLAN 10 and 20 PVID Configuration | 176 |
| 10.19 | Remove VLAN 1 membership | 176 |
| 10.20 | Management VLAN | 177 |
| 11.1 | Example static route configuration for Multi-WAN DNS services | 185 |
| 11.2 | Unequal cost load balancing configuration | 194 |
| 11.3 | Multi-WAN on a stick | 195 |
| 13.1 | Enable IPsec | 207 |
| 13.2 | Site A VPN Tunnel Settings | 208 |
| 13.3 | Site A Phase 1 Settings | 209 |
| 13.4 | Site A Phase 2 Settings | 210 |
| 13.5 | Site A Keep Alive | 210 |
| 13.6 | Apply IPsec Settings | 210 |
| 13.7 | Site B VPN Tunnel Settings | 211 |
| 13.8 | Site B Keep Alive | 212 |
| 13.9 | Site to Site IPsec | 213 |
| 13.10 | Site A - Static route to remote subnet | 214 |
| 13.11 | Site B - Static route to remote subnet | 214 |
| 13.12 | Enable Mobile IPsec Clients | 215 |
| 13.13 | Mobile Clients Phase 1 | 216 |
| 13.14 | Mobile Clients Phase 2 | 217 |
| 13.15 | Apply Mobile Tunnel Settings | 217 |
| 13.16 | IPsec Pre-shared Key "User" List | 218 |
| 13.17 | Adding an Identifier/Pre-Shared Key Pair | 218 |
| 13.18 | Applying Changes; PSK List | 218 |
| 13.19 | Shrew Soft VPN Access Manager - No Connections Yet | 220 |
| 13.20 | Client Setup: General Tab | 221 |
| 13.21 | Client Setup: Client Tab | 222 |
| 13.22 | Client Setup: Name Resolution Tab | 223 |
| 13.23 | Client Setup: Authentication, Local Identity | 224 |
| 13.24 | Client Setup: Authentication, Remote Identity | 225 |
| 13.25 | Client Setup: Authentication, Credentials | 226 |
| 13.26 | Client Setup: Phase 1 | 227 |
| 13.27 | Client Setup: Phase 2 | 228 |
| 13.28 | Client Setup: Policy | 229 |
| 13.29 | Client Setup: Policy, Add Topology | 230 |
| 13.30 | Client Setup: New Connection Name | 231 |
| 13.31 | Ready To Use Connection | 232 |
| 13.32 | Connected Tunnel | 233 |
| 14.1 | PPTP IP Addressing | 248 |
| 14.2 | PPTP VPN Firewall Rule | 249 |

| | | |
|-------|--|-----|
| 14.3 | PPTP WAN2 Firewall Rule | 250 |
| 14.4 | PPTP Users Tab | 250 |
| 14.5 | Adding a PPTP User | 251 |
| 14.6 | Applying PPTP Changes | 251 |
| 14.7 | List of PPTP Users | 252 |
| 14.8 | Network Connections | 252 |
| 14.9 | Network Tasks | 253 |
| 14.10 | Workplace Connection | 253 |
| 14.11 | Connect to VPN | 254 |
| 14.12 | Connection Name | 255 |
| 14.13 | Connection Host | 256 |
| 14.14 | Finishing the Connection | 257 |
| 14.15 | Connect Dialog | 258 |
| 14.16 | Connection Properties | 259 |
| 14.17 | Security Tab | 260 |
| 14.18 | Networking Tab | 261 |
| 14.19 | Remote Gateway Setting | 262 |
| 14.20 | Vista Network Connections | 263 |
| 14.21 | Setup A Connection | 263 |
| 14.22 | Connect to a Workplace | 263 |
| 14.23 | Connect using VPN | 263 |
| 14.24 | Connection Setup | 264 |
| 14.25 | Authentication Settings | 264 |
| 14.26 | Connection is Ready | 265 |
| 14.27 | Get Connection Properties | 265 |
| 14.28 | VPN Security Settings | 266 |
| 14.29 | VPN Networking Settings | 267 |
| 14.30 | VPN Gateway | 268 |
| 14.31 | Add network connection | 269 |
| 14.32 | Add PPTP VPN connection | 269 |
| 14.33 | Configure PPTP VPN connection | 270 |
| 14.34 | Advanced options | 271 |
| 14.35 | Connect to PPTP VPN | 271 |
| 14.36 | PPTP Logs | 274 |
| 15.1 | easy-rsa Backup | 279 |
| 15.2 | OpenVPN example remote access network | 288 |
| 15.3 | OpenVPN server WAN rule | 289 |
| 15.4 | OpenVPN example site to site network | 292 |
| 15.5 | OpenVPN example site to site WAN firewall rule | 293 |
| 15.6 | Assign tun0 interface | 294 |
| 15.7 | Example static route for OpenVPN Client on OPT WAN | 297 |
| 16.1 | Starting the Shaper Wizard | 304 |
| 16.2 | Shaper Configuration | 305 |
| 16.3 | Voice over IP | 305 |
| 16.4 | Penalty Box | 306 |
| 16.5 | Peer-to-Peer Networking | 307 |

| | | |
|-------|---|-----|
| 16.6 | Network Games | 307 |
| 16.7 | Raise or Lower Other Applications | 308 |
| 16.8 | Basic WAN Queues | 309 |
| 16.9 | Traffic Shaper Queues List | 310 |
| 16.10 | Traffic Shaper Rules List | 313 |
| 17.1 | Server load balancing example network | 320 |
| 17.2 | Pool configuration | 321 |
| 17.3 | Virtual Server configuration | 322 |
| 17.4 | Alias for web servers | 323 |
| 17.5 | Firewall rule for web servers | 324 |
| 17.6 | Firewall rule for web servers | 324 |
| 17.7 | Virtual Server status | 325 |
| 17.8 | Virtual Server status | 325 |
| 18.1 | Interface assignment - wireless WAN | 331 |
| 18.2 | Wireless WAN Associated | 332 |
| 18.3 | No carrier on wireless WAN | 333 |
| 18.4 | Wireless Status | 333 |
| 18.5 | Rules to allow only IPsec from wireless | 340 |
| 18.6 | Rules to allow only OpenVPN from wireless | 341 |
| 18.7 | Rules to allow only PPTP from wireless | 341 |
| 19.1 | Captive Portal on multiple subnets | 346 |
| 20.1 | Diagram of this network | 355 |
| 20.2 | WAN CARP IP | 356 |
| 20.3 | LAN CARP IP | 357 |
| 20.4 | Virtual IP list | 357 |
| 20.5 | Outbound NAT Entry | 358 |
| 20.6 | Advanced Outbound NAT Configuration | 359 |
| 20.7 | pfsync Interface Configuration | 360 |
| 20.8 | Firewall rule on pfsync interface | 361 |
| 20.9 | Diagram of Multi-WAN CARP with DMZ | 364 |
| 20.10 | DHCP Failover Pool Status | 365 |
| 20.11 | Diagram of CARP with Routed IPs | 368 |
| 20.12 | Diagram of CARP with Redundant Switches | 369 |
| 22.1 | DHCP Daemon Service Status | 381 |
| 22.2 | DNS Override Example | 383 |
| 22.3 | UPnP status screen showing client PCs with forwarded ports | 390 |
| 22.4 | pfSense system as seen by Windows 7 when browsing the Network | 391 |
| 23.1 | Example System Log Entries | 396 |
| 23.2 | System Status | 398 |
| 23.3 | Interface Status | 399 |
| 23.4 | Services Status | 400 |
| 23.5 | WAN Traffic Graph | 401 |

| | | |
|-------|---|-----|
| 23.6 | Example States | 403 |
| 23.7 | Example WAN Graph | 404 |
| 24.1 | Package information retrieval failed | 406 |
| 24.2 | Package Listing | 406 |
| 24.3 | Post-Install Package Screen | 407 |
| 24.4 | Installed Package List | 407 |
| 25.1 | Add new RADIUS client | 410 |
| 25.2 | Add new RADIUS client - name and client address | 411 |
| 25.3 | Add new RADIUS client - Shared secret | 412 |
| 25.4 | Listing of the RADIUS Client | 412 |
| 25.5 | IAS Ports | 413 |
| 25.6 | Configuring OpenDNS on pfSense | 414 |
| 25.7 | Windows Server DNS Properties | 415 |
| 25.8 | Windows Server DNS Forwarders | 416 |
| 25.9 | Add a network | 417 |
| 25.10 | Adding a dynamic IP connection | 418 |
| 25.11 | Adding a static IP connection | 419 |
| 25.12 | Network successfully added | 420 |
| 25.13 | Content filtering level | 421 |
| 25.14 | Manage individual domains | 421 |
| 25.15 | DNS servers alias | 422 |
| 25.16 | LAN rules to restrict DNS | 423 |
| 26.1 | Wireshark Capture View | 439 |

List of Tables

| | | |
|------|--|-----|
| 1.1 | RFC 1918 Private IP Address Space | 8 |
| 1.2 | CIDR Subnet Table | 10 |
| 1.3 | CIDR Route Summarization | 10 |
| 2.1 | Maximum Throughput by CPU | 18 |
| 2.2 | 1 Mpps throughput at various frame sizes | 19 |
| 2.3 | Large State Table RAM Consumption | 20 |
| 2.4 | IPsec Throughput by Encryption Protocol - ALIX | 20 |
| 2.5 | IPsec Throughput with Crypto Card - ALIX | 20 |
| 3.1 | Kernel Choices | 28 |
| 6.1 | Egress traffic required | 86 |
| 7.1 | /30 CIDR mapping - matching final octet | 122 |
| 7.2 | /30 CIDR mapping - non-matching final octet | 122 |
| 8.1 | WAN IP Block | 142 |
| 8.2 | Inside IP Block | 142 |
| 8.3 | Route Table Flags and Meanings | 147 |
| 10.1 | Netgear GS108T VLAN Configuration | 170 |
| 11.1 | Dissecting the ping monitoring | 182 |
| 11.2 | Unequal cost load balancing | 193 |
| 12.1 | Features and Characteristics by VPN Type | 202 |
| 13.1 | IPsec Endpoint Settings | 207 |
| 20.1 | WAN IP Address Assignments | 353 |
| 20.2 | LAN IP Address Assignments | 353 |
| 20.3 | pfsync IP Address Assignments | 354 |
| 20.4 | WAN IP Addressing | 362 |
| 20.5 | WAN2 IP Addressing | 362 |
| 20.6 | LAN IP Address Assignments | 363 |
| 20.7 | DMZ IP Address Assignments | 363 |
| 20.8 | pfsync IP Address Assignments | 363 |

| | | |
|------|--|-----|
| 26.1 | Real Interface vs. Friendly Names | 428 |
| 26.2 | tcpdump commonly used command line flags | 429 |
| 26.3 | Example uses of tcpdump -s | 430 |