Contents

1 **Basic routing** 9

1.1 Routing classification **11**

1.2 RouterOS routing components **11**

1.2.1 Router Information Base (RIB) 11

1.2.2 Forwarding Information Base (FIB) 13

1.2.3 How RIB and FIB tables are used 13

1.3 Default route **15**

1.4 Connected Routes **15**

1.5 Static routing **16**

1.6 Labs **17**

1.6.1 Static routing - guided 18

1.6.2 Static routing - without help 18

1.7 Summary questions **20**

1.7.1 Solutions 21

2 **Advanced static routing** 23

2.1 Types of load balancing **23**

2.2 Equal Cost Multi Path (ECMP) **24**

2.2.1 Lab 25

2.3 Administrative distance (distance) 28
2.3.1 Lab . . . 28
2.4 "Check-gateway" option 29
2.4.1 Lab . . . 29
2.5 Routing policies 31
2.5.1 Routing mark . . . 32
2.5.2 Lab . . . 32
2.5.3 Real case . . . 36
2.6 Life time (time to live - TTL) 37
2.7 Scope 37
2.7.1 Example . . . 40
2.7.2 Real case . . . 40
2.8 Types of routes 42
2.8.1 Lab . . . 42
2.9 Preferred source 45
2.10 Summary questions 46
2.10.1 Solutions . . . 47

3 OSPF: Open Shortest Path First . . . 49
3.1 Dynamic routing 49
3.1.1 Distance vector routing protocols . . . 50
3.1.2 Routing protocols based on link state . . . 51
3.2 OSPF 51
3.2.1 IGP, EGP e OSPF . . . 53
3.2.2 How OSPF works . . . 54
3.2.3 Area . . . 54
3.3 OSPF for RouterOS 60
3.3.1 Lab . . . 62
3.3.2 Loopback interface . . . 68
3.3.3 Virtual link . . . 68
3.3.4 DR e BDR . . . 71
3.3.5 Neighbors State . . . 72
3.3.6 Link State Advertisement . . . 73
3.3.7 Types of networks . . . 74
3.3.8 OSPF Redistribute Type . . . 75
3.3.9 Types of areas . . . 78
3.3.10 Passive interfaces . . . 81
3.3.11 Cost . . . 81
3.3.12 Redundancy . . . 82

3.4 Common problems of an OSPF installation and comparisons 82
3.5 Summary questions 82
3.5.1 Solutions . . . 83

4 BGP: Border Gateway Protocol . . . 85
4.1 How BGP works 85
4.1.1 What you can do with BGP . . . 87
4.1.2 What can't be done with BGP . . . 87
4.1.3 Criticalities and requirements . . . 88
4.2 BGP with Mikrotik RouterOS 88
4.2.1 Lab . . . 88
4.2.2 Lab . . . 92
4.2.3 Useful links . . . 95

5 802.1q . . . 97
5.1 The 802.1q standard 98
5.1.1 Ports types . . . 98
5.2 VLAN on RouterOS 99
5.2.1 Lab on trunk propagated among switches . . . 101
5.2.2 Lab . . . 103
5.2.3 Comparison of configurations . . . 108
5.2.4 Important note on performance . . . 111
5.3 RouterOS /32 and IP addresses unnumbered IP 111
5.4 Summary questions 112
5.4.1 Solutions . . . 112

6 Tunnel . . . 113
6.1 Virtual Private Network 113
6.2 Tunnel 114
6.2.1 IP addresses on point-to-point networks . . . 116
6.3 IP-in-IP 118
6.3.1 GRE vs IPIP . . . 119
6.3.2 Lab . . . 120
6.4 EoIP 124
6.4.1 How the protocol works . . . 124
6.4.2 Lab . . . 124
6.5 IPsec 127
6.5.1 How the protocol works . . . 127
6.5.2 IPsec on RouterOS . . . 129

6.6 IPsec/XAuth 133
6.7 MPLS 136
6.7.1 How the protocol works . . . 136
6.7.2 MPLS and VPLS using Mikrotik RouterOS . . . 140

A Useful schemes and tables . . . 147
A.1 Block diagram of packet flow 148
A.2 Differences between Cisco IOS and Mikrotik RouterOS 149
A.2.1 Generic routing . . . 149
A.2.2 OSPF . . . 149
A.2.3 MPLS . . . 150

Index . . . 151

Index

Symbols

802.1q 98

A

ABR (Area border router) 55
AH (Authentication Header) 127
AS (Autonomous system) 49
ASBR (Autonomous system boundary router) 55

B

BDR (Backup designated router) 56
BGP (Border Gateway Protocol) 53, 85
BUM traffic 140

C

CE (Customer Edge) 140
Check-Gateway 29

D

Dijkstra algorithm 51
Distance 28
Distance vector 50
DPD (Dead Peer Detection) 130
DR (Designated router) 56

E

eBGP (External Border Gateway Protocol) . 85
ECMP (Equal Cost Multi Path) 24, 25
EIGRP 53
EoIP (Ethernet over IP) 124
ESP (Encapsulating Security Payload) . . . 128
Exterior router 49

F

FEC (Forwarding Equivalent Class) 138
FIB (Forwarding Information Base) 13

I

iBGP (Interior Border Gateway Protocol) . . 85

IGRP 53
IKE (Internet Key Exchange) 128
Internal router 49, 55
IP-in-IP 118
IPIP 118
IPsec
    XAuth 133
IPsec (IP SECurity) 127
    Transport mode 128
    Tunnel mode 128
IXP (Internet Exchange Point) 87

L

Link state 51
Load balancing 23
Longest match 138
LSA (Link state advertisement) 55
LSP (Label Switched Path) 137
LSP tunnel 139
    Pipe Model 139
    Uniform Model 139
LSR (Label Switching Router) 139

M

Metric 60
    external 75
MPLS (Multi Protocol Label Switching) . . 136

N

NBMA (Non-Broadcast Multi-Access) 75
Neighbor adjacency 56
Next hop 37

O

OSPF
    area 62
    instance 60
    network 62
OSPF (Open Shortest Path First) 54

P

PA (Provider Allocatable) 88
Performance 111, 141
PI (Provider Indipendent) 88
Port
    access 99
    core 99
    edge 99
    tagged 99
    trunk 99
    untagged 99
Preferred source 45
PVC (Private virtual circuit) 75

R

RFC
    1771 85
    2003 118
    2328 . . . . . 68, 74
    2401 127
    2402 127
    2406 127
    2409 127
    2684 140
    2784 119
    2890 119
    3031 138
RIB (Router Information Base) 11
Route
    connected 15
    default 15
    static 18
Route flags 12
Routing
    mark 32
    policy 31

S

SA (Security Association) 128
SAD (SA Database) 129
Scope 37

Sniffing 127
SPD (Security Policy Database) 129
SPF (Shortest path first) 51
Spoofing 127

T

Target scope 37
TTL 37
Types of routes 42

U

Unnumbered IP 111

V

VFI (Virtual Forwarding Instance) 140
VID (VLAN Identificator) 97
VLAN (Virtual LAN) 97
VPLS (Virtual Private LAN Service) 139
VPN (Virtual Private Network) 113
    overlay 114
    peer-to-peer 114
VSI (Virtual Switch Interface) 140