

Table of Contents

Preface	xi
Chapter 1. Network Operation	1
1.1. Basic concepts	1
1.1.1. Layered structure	1
1.1.2. LANs	3
1.1.3. WANs networks	5
1.1.4. Protocol architecture	6
1.1.5. Addressing principles	8
1.2. IP technology.	9
1.2.1. Routing	9
1.2.2. The IPv4 protocol.	10
1.2.3. The IPv6 protocol.	12
1.3. The MPLS technology	14
1.3.1. Label switching	14
1.3.2. Tables in the LSR.	15
1.3.3. The PHP function.	16
1.3.4. The format of the MPLS header	16
1.3.5. Encapsulation of a labeled packet	18
1.4. The ICMP.	19
1.5. Ethernet technology	22
1.5.1. The physical layer	22
1.5.2. The data link layer	24
Chapter 2. Characterizing Quality of Service	27
2.1. Quality of service functions	27
2.2. Quality of network operation	29
2.2.1. Availability	29

2.2.2. Admissibility	32
2.2.3. Loss ratio	33
2.2.4. Delay	34
2.2.5. Jitter	34
2.2.6. Classes of service	34
2.2.7. Bandwidth	35
2.3. Requirements of applications	36
2.3.1. Voice	36
2.3.2. Video	41
2.3.3. Application and control data	43
2.4. The service contract	44
2.4.1. The “Enterprise” section	46
2.4.2. The “Service” section	47
2.4.3. The “Technology” section	48
2.4.4. The Quality of Service report	50
Chapter 3. Transport Protocols	51
3.1. Introduction	51
3.2. The TCP	52
3.2.1. Format of the TCP header	52
3.2.2. Initiating and closing a connection	54
3.2.3. Data transfer	55
3.2.4. The slow start and congestion avoidance mechanisms	56
3.2.5. The fast retransmit and fast recovery mechanisms	57
3.2.6. The ECN mechanism	58
3.3. The UDP	59
3.3.1. Format of the UDP header	60
3.4. The RTP	60
3.4.1. Format of the RTP header	61
3.5. The RTCP	62
3.5.1. Format of the SR message	63
3.5.2. Format of the RR message	65
3.6. The DCCP	65
3.6.1. DCCP procedure	66
3.6.2. Congestion control	67
3.6.3. Format of the DCCP header	67
3.6.4. Options	69
3.7. The SCTP	70
3.7.1. Format of the SCTP header	71
3.7.2. Association	72
3.7.3. Data transfer	73

Chapter 4. Implementing Operation Quality	77
4.1. The architectural framework.	77
4.2. Implementation of resource management	77
4.2.1. Relative QoS.	78
4.2.2. Guaranteed QoS.	79
4.2.3. Resource reservation scenarios.	80
4.2.4. Mechanisms associated with the user plane	83
4.2.5. Load balancing	92
4.2.6. Link optimization mechanisms.	92
4.3. Implementing fault management	96
4.3.1. Network reconfiguration.	96
4.3.2. Fault detection.	97
4.3.3. Equipment reconfiguration	98
Chapter 5. IP Technology – Resource Management.	101
5.1. Introduction.	101
5.2. The DiffServ model	102
5.2.1. The DSCP field	102
5.2.2. The DiffServ architecture	106
5.3. The IntServ model.	109
5.3.1. Principles of resource reservation	109
5.3.2. The RSVP	110
5.4. The ARSVP protocol	123
5.4.1. Principles of aggregation	123
5.4.2. The ARSVP procedure.	124
Chapter 6. IP Technology – Fault Management	127
6.1. Introduction.	127
6.2. Hot Standby Router Protocol	128
6.2.1. Operating principles	128
6.2.2. Format of the HSRP message.	129
6.2.3. Load balancing	131
6.3. Virtual Router Redundancy Protocol.	132
6.3.1. Operating principles	132
6.3.2. Format of the VRRP message	132
6.4. OSPF protocol	134
6.4.1. Operating principles	134
6.4.2. Format of the OSPF message	135
6.4.3. Restarting the OSPF protocol.	139
6.5. Border Gateway Protocol.	144
6.5.1. Operating principles	144

6.5.2. Format of the BGP message	145
6.5.3. Path attributes	147
6.5.4. Route selection	148
6.5.5. BGP restart.	149
Chapter 7. MPLS Technology – Resource Management	153
7.1. Introduction.	153
7.2. Support for DiffServ	154
7.2.1. Types of virtual circuits	154
7.2.2. Interaction between markings.	156
7.3. Traffic engineering	158
7.3.1. Operating principles	158
7.3.2. The RSVP-TE protocol	160
7.3.3. OSPF-TE protocol	174
Chapter 8. MPLS Technology – Fault Management	177
8.1. Introduction.	177
8.2. The LDP	178
8.2.1. Operating principles	178
8.2.2. Format of the LDP PDU.	180
8.2.3. The LDP messages	182
8.2.4. Restarting the LDP	185
8.3. The RSVP-TE protocol.	189
8.3.1. Failure detection	189
8.3.2. Restarting the RSVP-TE protocol	190
8.4. The FRR mechanism	193
8.4.1. Operating principles	193
8.4.2. Extensions of the RSVP-TE protocol	195
8.4.3. Procedure of the FRR mechanism	199
Chapter 9. Ethernet Technology – Resource Management	203
9.1. Introduction.	203
9.2. Priority management	204
9.3. Resource reservation	207
9.3.1. The bandwidth manager	207
9.3.2. The SBM protocol	209
9.4. Flow control	216
9.5. The access network	217
9.5.1. Architecture of the PON.	218
9.5.2. Priority management in EPON	220
9.5.3. Priority management in GPON	221
9.6. The aggregation network	224

Chapter 10. Ethernet Technology – Fault Management	227
10.1. Introduction	227
10.2. The STP	228
10.2.1. Operating principles	228
10.2.2. Format of the BPDU message.	229
10.2.3. Procedure of the STP	231
10.3. The RSTP	233
10.3.1. Operating principles	233
10.3.2. Format of the BPDU message.	234
10.3.3. Procedure of the RSTP	235
10.4. The MSTP	237
10.4.1. Operating principles	237
10.4.2. Format of the BPDU message.	238
10.4.3. Procedure of the MSTP	240
10.5. Link aggregation	242
10.5.1. Operating principles	242
10.5.2. The LACP message	243
10.5.3. The Marker protocol	245
10.6. The aggregation network	246
10.6.1. Operating principles	246
10.6.2. The APS protocol	248
Conclusion	251
Bibliography	255
Abbreviations	259
Index	265