
Contents

1	Introduction and Overview	1
1.1	On the Interest in SS 7 Network Security and Reliability	1
1.2	Basic Developments in Telecommunications	3
1.3	MTP Procedures, Network Structure, and SS 7 Network Outages	6
2	Development and Fundamental Conception of SS 7	7
2.1	Basic Concepts	7
2.1.1	The Fundamental Philosophy of SS 7	7
2.1.2	Fundamental Requirements	8
2.1.3	The Functional Levels of the MTP	9
2.2	The Realization of the ISDN Concept	11
2.3	Further Development of the SS 7 Structure	12
2.3.1	OSI Layering	12
2.3.2	OAM, Mobile, and IN Applications	12
2.3.3	Broadband ISDN	13
2.3.4	PSTN and IP Network Convergence	15
3	On the Specification of the MTP	19
3.1	Flow Control	19
3.2	User Flow Control	22
3.3	Processor Outage	23
3.4	Restart Procedure	25
3.5	Management Inhibiting	27
3.6	Load Sharing	28
3.7	The Status of the MTP Procedures	29
4	SS 7 over IP Networks	31
4.1	The Distributed IP Telephony Model	31
4.2	Signalling Requirements	32
4.3	Framework Architecture for Signalling Transport	33

5	SS 7 over IP Signalling Transport Protocol Architectures	35
5.1	Signalling Transport Using M2PA and IP-Based High-Speed Links	35
5.2	Signalling Transport Using M2UA	37
5.3	Signalling Transport Using M3UA	38
5.4	Signalling Transport Using SUA	41
6	SS7 over IP Signalling Network Architectures	45
6.1	SS 7 User Part Representation and Addressing in the IP Domain	46
6.1.1	The Application Server and Application Server Process	46
6.1.2	The Signalling Point Management Cluster	47
6.1.3	The Network Address Translation and Mapping Function	47
6.2	Application Server Redundancy	48
6.2.1	ASP States	48
6.2.2	AS States	49
6.2.3	Maintenance of ASP and AS States	49
6.2.4	ASP Failover and Failback	52
6.3	Signalling Point Code Representation	53
6.4	Physical Network Architectures	54
6.4.1	Alternative SCTP Associations	54
6.4.2	Signalling Gateway Redundancy	54
7	SS7 over IP Protocol Description	57
7.1	Internet Protocol	57
7.1.1	Internet Addressing	57
7.1.1.1	IP Addresses	58
7.1.1.2	Subnetting	59
7.1.1.3	MAC/IP Address Translation	60
7.1.1.4	Multi-homing	60
7.1.2	Routing Principles	61
7.1.3	IP Services and Functions	62
7.1.4	The IP Datagram Structure	64
7.1.5	The Internet Control Message Protocol	66
7.1.5.1	The Basic ICMP Message Format	67
7.1.5.2	ICMP Error Messages	67
7.1.5.3	ICMP Query Messages	69
7.2	Stream Control Transmission Protocol	69
7.2.1	Basic SCTP Packet Format	70
7.2.2	Association Initialization and Termination	72
7.2.2.1	Association Establishment	72
7.2.2.2	Association Restart	75
7.2.2.3	Association Termination	76
7.2.3	User Data Transfer	77
7.2.3.1	Assembly of SCTP Packets	78
7.2.3.2	Disassembly of SCTP Packets	80
7.2.3.3	Transmission and Retransmission of DATA Chunks	84

7.2.4	Congestion Control	85
7.2.4.1	The Congestion Window Mechanism	85
7.2.4.2	Slow Start	87
7.2.4.3	Congestion Avoidance	87
7.2.4.4	Congestion	88
7.2.5	Path Management	88
7.2.6	Fault Management	89
7.2.6.1	Endpoint Failure Detection	89
7.2.6.2	Path Failure Detection	90
7.2.6.3	Operation Errors	90
7.3	MTP-2 User Peer-to-Peer Adaptation Layer	91
7.3.1	M2PA Messages	91
7.3.2	Management of SCTP Associations	93
7.3.3	Interface Boundaries	95
7.3.4	M2PA-Specific Functions	95
7.4	MTP-2 User Adaptation Layer	98
7.4.1	M2UA Messages	98
7.4.2	Management of SCTP Associations	99
7.4.3	Interface Boundaries	101
7.4.4	M2UA-Specific Functions	102
7.4.5	M2UA Management	104
7.5	MTP-3 User Adaptation Layer	104
7.5.1	M3UA Messages	105
7.5.2	Management of SCTP Associations	105
7.5.3	Interface Boundaries	108
7.5.4	M3UA-Specific Functions	108
7.5.4.1	Routing Key Management	108
7.5.4.2	Interworking of Network Management Functions ..	109
7.5.5	M3UA Management	113
7.6	SCCP User Adaptation Layer	113
7.6.1	SUA Messages	114
7.6.2	Management of SCTP Associations	114
7.6.3	Interface Boundaries	117
7.6.4	SUA-Specific Functions	119
7.6.4.1	Addressing	119
7.6.4.2	Routing Key Management	120
7.6.4.3	Interworking of Network Management Functions ..	121
7.6.5	SUA Management	124
8	SS 7 Network Outages	127
8.1	On the Failure of Links and Exchanges	127
8.2	The Spread of Local Problems within the SS 7 Network	128
8.3	The Outage and Isolation of Large Network Areas	130

9	SS 7 Flow Control	133
9.1	MTP Flow Control	133
9.1.1	Level 2 Flow Control	134
9.1.2	Signalling Traffic Flow Control	134
9.1.3	National Option with Congestion Priorities	136
9.2	ISUP Congestion Control	138
9.3	SCCP Congestion Control and Load Reduction of Application Parts	140
9.3.1	SCCP Congestion	141
9.3.2	SCCP Flow Control	141
9.3.3	Congestion Report	142
9.3.4	Traffic Limitation	143
9.4	The Function of the SS 7 Flow Control	144
9.5	SS 7 over IP and Flow Control	146
9.5.1	IP Flow Control	147
9.5.2	SCTP Flow Control	148
9.5.2.1	SCTP Streams	148
9.5.2.2	Traffic Mixing and Flow Control	149
9.5.2.3	Stream-Based Flow Control	150
10	MTP Restart Procedure	153
10.1	Problems with the Blue Book Restart Procedure	153
10.1.1	The Blue Book Restart Procedure	154
10.1.2	Problems with Early User Traffic	156
10.1.3	Problems with Restarting Signalling Points with no Transfer Function	156
10.1.4	Loss of Bidirectionality	158
10.2	Further Problems with the Restart Procedure	159
10.2.1	Unexpected TRA Messages	159
10.2.2	Short-Term Isolations	160
10.2.3	Late Events	161
10.2.4	Link Activation and Routing Data Update	162
10.2.5	Network Outages	162
10.3	Interworking Problems with the MTP Restart Procedure	163
10.3.1	Problems with a Restarting SEP	164
10.3.1.1	Problems with a Restarting Red Book Node	164
10.3.1.2	Problems with a Restarting Blue Book Node	165
10.3.1.3	Problems with a Restarting White Book Node	167
10.3.2	Problems with a Restarting STP	168
10.3.2.1	Problems with a Restarting Red Book Node	168
10.3.2.2	Problems with a Restarting Blue Book Node	169
10.3.2.3	Problems with a Restarting White Book Node	169
10.3.3	White Book STP and Red Book SEP Interworking Problems	170
10.3.3.1	The Traffic Restart Waiting Method	171
10.3.3.2	Reducing the Outage Time of Restarting Red Book SEPs	172

10.3.3.3	Restarting White Book STP and Adjacent Red Book SEPs	173
10.3.3.4	Conclusions	174
10.4	The White Book Restart Procedure	176
11	Real SS 7 Networks	179
11.1	The Physical Network	180
11.2	The Logical Network	181
11.2.1	Node-Disjoint Routes and Bidirectionality	181
11.2.2	Local and Global Routes	182
11.3	Routing and Topology	183
11.3.1	The Network Topology	183
11.3.2	The Creation of Routing Data	186
11.3.3	Loop-Freeness, Bidirectionality, and Node-Disjoint Routes	187
11.3.4	Network Changes	188
11.4	Network Interconnection	188
11.4.1	Intermediate Networks	188
11.4.2	Network Interconnection via Signalling Gateways	190
11.4.3	Access to IN Services	191
12	Potential Problems in Real SS 7 Networks	193
12.1	On the Application of the MTP	193
12.2	Problems with the Network Size	194
12.2.1	Routing Problems	195
12.2.2	Mass Problems with SRM Messages	195
12.2.3	Problems with the MRVT	196
12.3	Problems with the Flow Control	198
12.3.1	The Influence of Different Applications	201
12.3.2	Network Dependence of the Flow Control	203
12.3.3	The Influence of Signalling Scenarios	205
12.3.4	The Influence of Repeated Call Attempts	206
12.3.5	Loss of Messages Caused by Congestion Situations	208
12.3.6	Insufficient Measures in the Case of Level 3 Congestions	210
12.4	The Network Dependence of the MTP Restart Procedure	210
12.4.1	Problems with the Routing Data Update	210
12.4.2	Problems with Late Events	212
12.4.3	Problems with Preventive TFPs	212
12.4.4	Problems with the User Part Information	212
12.5	Problems with the User Part Availability Control	213
12.6	Consequences of a Loss of Bidirectionality	213
12.6.1	Bidirectionality and Changeover	216
12.6.2	Bidirectionality and Changeback	216
12.6.3	Bidirectionality and MTP Restart	217
12.6.4	Bidirectionality and Flow Control	218
12.6.5	Bidirectionality and User Flow Control	219

12.6.6	Bidirectionality and Inhibiting	219
12.7	Problems with Signalling Loops	220
12.7.1	Consequences of Signalling Loops	220
12.7.2	How to Avoid Signalling Loops	221
12.7.3	Preventive TFPs on Routes with Highest Priority	222
12.7.4	Problems with Specific Network Structures	222
12.8	Problems with Signalling Gateways	223
12.8.1	Problems with MTP Procedures	223
12.8.2	Network Security Aspects	225
12.8.3	Problems with PSTN and IP Network Convergence	226
12.8.3.1	Large Amounts of SRM Messages	226
12.8.3.2	Signalling Gateway Restart	226
12.8.3.3	Signalling Gateway Congestion	228
12.8.3.4	SPMC Inaccessibility and User Part Unavailability in the IP Domain	229
13	How to Avoid SS 7 Network Outages	231
13.1	Specific Measures to Avoid SS 7 Network Outages	231
13.1.1	General Discussion	231
13.1.2	On the Possibility of Realizing the Described Measures	233
13.2	New Network Concepts	234
13.2.1	Examples of Network Topologies	234
13.2.1.1	Hierarchical Network with Two Node-Disjoint Routes	234
13.2.1.2	Hierarchical Network with Three Node-Disjoint Routes	235
13.2.1.3	Nonhierarchical Network with Three Node-Disjoint Routes	236
13.2.1.4	Creating Network Areas	236
13.2.2	ATM- and IP-Based SS 7 Networks	239
13.2.3	Increasing Reliability by Changing the Network Structure ..	240
13.2.4	On the Need for Standalone STPs	241
13.3	SS 7 over IP Applications	242
13.3.1	Increasing Reliability with IP-Based High-Speed Links	243
13.3.2	Separation of Different Traffic Streams	244
13.3.2.1	M2PA-Based IP Networks	244
13.3.2.2	M3UA-Based IP Networks	246
13.3.3	Simplified Point-to-Point Relationship	247
13.3.4	How to Avoid Problems with Network Convergence	249
14	Migration to an IP-Based Network	251
14.1	General Discussion on PSTN and IP Network Convergence	251
14.2	Protocol Structures for an IP-Based SS 7 Network	254

Appendix A: Timer Values	258
A.1 MTP Level 2 Timer Values	259
A.2 MTP Level 3 Timer Values	259
A.3 SCTP Timers and Protocol Parameter Values	261
A.4 M2UA and M3UA Timer Values	261
A.5 SUA Timer Values	261
Appendix B: Abbreviations	261
References	269
Index	273