Contents

Foreword *ix*
Acknowledgments *xi*

1. Introduction **1**
1.1 5G—A new era of connectivity 1
1.2 A step change 1
1.3 A new context for operators 2
1.4 The road to 5G network deployments 2
1.5 3GPP release 15 and 16 2
1.6 Core requirements 4
1.7 New service grades 4
1.8 Structure of this book 5

2. Drivers for 5G **7**
2.1 Introduction 7
2.2 New use cases 7
2.3 New technologies 9

3. Architecture overview **15**
3.1 Introduction 15
3.2 Two perspectives on 5G Core 19
3.3 Service-based architecture (SBA) 22
3.4 The core of the core 26
3.5 Connecting the core network to mobile devices and radio networks 28
3.6 Mobility and data connectivity 30
3.7 Policy control and charging 35
3.8 5GC interworking with EPC 37
3.9 Voice services 41
3.10 Messaging services 44
3.11 Exposure of network information 46
3.12 Device positioning services 48
3.13 Network analytics 49
3.14 Public warning system 50
3.15 Support for devices connected over non-3GPP access networks 52
3.16 Network slicing 54
3.17 Roaming 55

3.18 Storage of data 59
3.19 5G radio networks 59

4. EPC for 5G 73
4.1 Introduction 73
4.2 Key EPC functions 77
4.3 (Enhanced) Dedicated Core Networks ((e)DECOR) 84
4.4 Control and User Plane Separation (CUPS) 89

5. Key concepts 105
5.1 Architecture modeling 105
5.2 Service Based Architecture 105
5.3 Identifiers 107

6. Session management 111
6.1 PDU Session concepts 111
6.2 PDU Session types 114
6.3 User plane handling 121
6.4 Mechanisms to provide efficient user plane connectivity 126
6.5 Edge computing 132
6.6 Session authentication and authorization 134
6.7 Local Area Data Network 135

7. Mobility Management 137
7.1 Introduction 137
7.2 Establishing connectivity 138
7.3 Reachability 144
7.4 Additional MM related concepts 146
7.5 N2 management 150
7.6 Control of overload 157
7.7 Non-3GPP aspects 161
7.8 Interworking with EPC 162

8. Security 171
8.1 Introduction 171
8.2 Security requirements and security services of the 5G system 172
8.3 Network access security 176
8.4 Network domain security 192
8.5 User domain security 198
8.6 Lawful intercept 198

9. Quality-of-Service 203

9.1 Introduction 203
9.2 Flow based QoS framework 205
9.3 Signaling of QoS 207
9.4 Reflective QoS 210
9.5 QoS parameters and characteristics 213

10. Policy control and charging 217

10.1 Introduction 217
10.2 Overview of policy and charging control 217
10.3 Access and mobility related policy control 222
10.4 UE policy control 224
10.5 Management of Packet Flow Descriptions 227
10.6 Network status analytics 228
10.7 Negotiation for future background data transfer 228
10.8 Session Management related policy and charging control 229
10.9 Additional session related policy control features 237
10.10 Charging 242

11. Network slicing 247

11.1 Introduction 247
11.2 Management and orchestration 249
11.3 Network Slice selection framework 251

12. Dual connectivity 265

12.1 Introduction 265
12.2 Multi-RAT Dual Connectivity overall architecture 268
12.3 MR-DC: UE and RAN perspective 272
12.4 MR-DC: Subscription, QoS flows and E-RABs, MR-DC bearers 274
12.5 Managing secondary RAN node handling for mobility and session management 278
12.6 Security 282
12.7 Reporting User Data Volume traversing via SN 283

13. Network functions and services 287

13.1 5G core network functions 287
13.2 Services and service operations 293

14. Protocols 337

14.1 Introduction 337
14.2 5G non-access stratum (5G NAS) 337

14.3 NG application protocol (NGAP) 343
14.4 Hypertext transfer protocol (HTTP) 347
14.5 Transport layer security (TLS) 360
14.6 Packet forwarding control protocol (PFCP) 363
14.7 GPRS tunneling protocol for the User Plane (GTP-U) 378
14.8 Extensible Authentication Protocol (EAP) 379
14.9 IP security (IPSec) 382
14.10 Stream Control Transmission Protocol (SCTP) 387
14.11 Generic routing encapsulation (GRE) 392

15. Selected call flows 395
15.1 Introduction 395
15.2 Registration and deregistration 396
15.3 Service Request 400
15.4 UE Configuration Update 404
15.5 PDU Session Establishment 407
15.6 Inter-NG-RAN handover 409
15.7 EPS interworking with N26 416
15.8 EPS fallback 422
15.9 Procedures for untrusted non-3GPP access 424

16. Architecture extensions and vertical industries 431
16.1 Overview 431
16.2 Architecture enhancements and extensions 431
16.3 New feature capabilities 437

17. Future outlook 465

References 467
Abbreviations 471
Index 475