

Contents

List of Contributors	xiii
Preface	xv
1 Commercial and Public Use Applications	1
<i>Dr. Hariharan Krishnan, Dr. Fan Bai and Dr. Gavin Holland</i>	
1.1 Introduction	2
1.1.1 Motivation	3
1.1.2 Contributions and benefits	3
1.1.3 Chapter organization	4
1.2 V2X Applications from the User Benefits Perspective	4
1.2.1 Application value	5
1.3 Application Characteristics and Network Attributes	8
1.3.1 Application characteristics	8
1.3.2 Network attributes	10
1.4 Application Classification and Categorization	12
1.4.1 Characterization based on application characteristics	12
1.4.2 Characterization based on network attributes	15
1.4.3 Application classification	18
1.5 Market Perspectives and Challenges for Deployment	21
1.5.1 Fleet penetration	21
1.5.2 System rollout options	21
1.5.3 Market penetration analysis	23
1.5.4 System rollout	25
1.5.5 Role of infrastructure	25
1.6 Summary and Conclusions	26
References	27
2 Governmental and Military Applications	29
<i>Anthony Maida</i>	
2.1 Introduction	29
2.2 Vehicular Networks for First Responders	30
2.2.1 Public safety communications	30
2.2.2 Vehicular communications	31

2.3	The Need for Public Safety Vehicular Networks	33
2.4	State of Vehicular Network Technology	35
2.4.1	Incident Area Networks	35
2.4.2	Jurisdictional Area Networks	36
2.4.3	Extended Area Networks	38
2.5	Vehicular Networks for Military Use	40
2.6	Conclusions	42
	References	42
3	Communication Systems for Car-2-X Networks	45
	<i>Daniel D. Stancil, Fan Bai and Lin Cheng</i>	
3.1	Overview of the V2X Environment	46
3.1.1	Vehicle-to-Infrastructure	46
3.1.2	Vehicle-to-Vehicle	46
3.1.3	Antenna requirements	47
3.2	V2X Channel Models	48
3.2.1	Deterministic models	48
3.2.2	Geometry-based statistical models	48
3.2.3	Multi-tap models	50
3.3	V2X Channel Properties	50
3.3.1	Empirical measurement platform	51
3.3.2	Large-scale path loss	51
3.3.3	Fading statistics	53
3.3.4	Coherence time and Doppler spectrum	53
3.3.5	Coherence bandwidth and delay spread profile	56
3.4	Performance of 802.11p in the V2X Channel	58
3.4.1	Impact of channel properties on OFDM	59
3.4.2	Potential equalization enhancement schemes	61
3.5	Vehicular Ad hoc Network Multichannel Operation	61
3.5.1	Multichannel MAC (IEEE 1609.4)	62
3.5.2	Performance evaluation of the IEEE 1609.4 multichannel MAC	63
3.5.3	Other solutions for multichannel operations	65
3.6	Vehicular Ad hoc Network Single-hop Broadcast and its Reliability Enhancement Schemes	66
3.6.1	Reliability analysis of DSRC single-hop broadcast scheme	66
3.6.2	Reliability analysis of DSRC-based VSC applications	68
3.6.3	Reliability enhancement schemes for single-hop broadcast scheme	69
3.7	Vehicular Ad hoc Network Multi-hop Information Dissemination Protocol Design	71
3.7.1	Multi-hop broadcast protocols in dense VANETs	71
3.7.2	Multi-hop broadcast protocols in sparse VANETs	73
3.8	Mobile IP Solution in VANETs	75
3.8.1	Mobile IP solution	75
3.8.2	Mobile IP solution tailored to VANET scenarios	76
3.9	Future Research Directions and Challenges	77
3.9.1	Physical layer perspective	77
3.9.2	Networking perspective	77
	References	78

4 Communication Systems for Railway Applications 83

Benoît Bouchez and Luc de Coen

- 4.1 Evolution of Embedded Computers and Communication Networks in Railway Applications 83
- 4.2 Train Integration in a Global Communication Framework 84
- 4.3 Communication Classes and Related Communication Requirements 85
 - 4.3.1 Real-time data 85
 - 4.3.2 Non-real-time message data 86
 - 4.3.3 Streaming data 88
- 4.4 Expected Services from a Railway Communication System and the Related Requirements 88
 - 4.4.1 Automatic Train Control 88
 - 4.4.2 Passenger Information System 89
 - 4.4.3 Video 90
 - 4.4.4 Maintenance 91
 - 4.4.5 On-board Internet access 91
- 4.5 Qualitative and Quantitative Approach for Dimensioning Wireless Links 92
 - 4.5.1 Environmental influence 92
 - 4.5.2 Global propagation model 92
 - 4.5.3 Train motion influence 93
 - 4.5.4 Regulation and licensing 93
- 4.6 Existing Wireless Systems Applicable to Railway Communication Systems 93
 - 4.6.1 Magnetic coupling technology 93
 - 4.6.2 WLAN/WMAN technologies 94
 - 4.6.3 Cellular technologies 96
 - 4.6.4 Satellite link technologies 99
- 4.7 Networks for On-board Communication and Coupling with the Wayside 99
 - 4.7.1 Multifunction Vehicle Bus 99
 - 4.7.2 Wire Train Bus 100
 - 4.7.3 Ethernet 100
 - 4.7.4 Coupling on-board communication with wayside communication 100
- 4.8 Integration of Existing Technologies for Future Train Integration in a Global Communication Framework 101
 - 4.8.1 European Rail Traffic Management System 101
 - 4.8.2 MODURBAN Communication System 102
- 4.9 Conclusion 103
- References 103

5 Security and Privacy Mechanisms for Vehicular Networks 105

Panos Papadimitratos

- 5.1 Introduction 105
- 5.2 Threats 107
- 5.3 Security Requirements 108
- 5.4 Secure VC Architecture Basic Elements 109
 - 5.4.1 Authorities 109
 - 5.4.2 Node identification 110
 - 5.4.3 Trusted components 110
 - 5.4.4 Secure communication 111

5.5	Secure and Privacy-enhancing Vehicular Communication	111
5.5.1	Basic security	111
5.5.2	Secure neighbor discovery	112
5.5.3	Secure position-based routing	113
5.5.4	Additional privacy-enhancing mechanisms	113
5.5.5	Reducing the cost of security and privacy enhancing mechanisms	115
5.6	Revocation	116
5.7	Data Trustworthiness	119
5.7.1	Securing location information	119
5.7.2	Message trustworthiness	121
5.8	Towards Deployment of Security and PET for VC	122
5.8.1	Revisiting basic design choices	122
5.8.2	Future challenges	124
5.9	Conclusions	125
	References	125
6	Security and Dependability in Train Control Systems	129
	<i>Mark Hartong, Rajni Goel and Duminda Wijesekera</i>	
6.1	Introduction	130
6.2	Traditional Train Control and Methods of Rail Operation	130
6.2.1	Verbal authority and mandatory directives	131
6.2.2	Signal indications	131
6.3	Limitations of Current Train Control Technologies	132
6.4	Positive Train Control	132
6.4.1	Functions	133
6.4.2	Architectures	134
6.4.3	US communication-based systems	135
6.5	System Security	138
6.5.1	The security threat	138
6.5.2	Attacks	139
6.5.3	Required security attributes	141
6.5.4	Analysis of requirements	142
6.6	Supplementary Requirements	144
6.6.1	Performance management	144
6.6.2	Configuration management	145
6.6.3	Accounting, fault, and security management	145
6.7	Summary	146
	References	146
7	Automotive Standardization of Vehicle Networks	149
	<i>Tom Schaffnit</i>	
7.1	General Concepts	149
7.1.1	Vehicle-to-Vehicle communications	150
7.1.2	Vehicle-to-Infrastructure communications	150
7.2	Interoperability	151
7.2.1	Regional requirements and differences	152
7.2.2	Necessity of standards	153
7.2.3	Insufficiency of standards	154

- 7.3 Wireless Protocols and Standardization Activities 154
 - 7.3.1 OSI seven-layer protocol model 154
 - 7.3.2 Standards activities relative to protocol layers 155
 - 7.3.3 Cooperation required among different standards 156
- 7.4 Regional Standards Development Progress 157
 - 7.4.1 North America 157
 - 7.4.2 Europe 160
 - 7.4.3 Japan 162
- 7.5 Global Standardization 163
 - 7.5.1 Global standards development organizations and mechanisms 164
 - 7.5.2 Allowances for regional differences 167
- References 168

- 8 Standardization of Vehicle-to-Infrastructure Communication 171**
Karine Gosse, David Bateman, Christophe Janneteau, Mohamed Kamoun, Mounir Kellil, Pierre Roux, Alexis Olivereau, Jean-Noël Patillon, Alexandru Petrescu, and Sheng Yang
 - 8.1 Introduction 172
 - 8.2 Overview of Standards and Consortia Providing Vehicle-to-Infrastructure Communication Solutions 173
 - 8.2.1 Spectrum 173
 - 8.2.2 Standards 174
 - 8.3 Radio Access Standards for V2I Communications 178
 - 8.3.1 IEEE 802.11p 178
 - 8.3.2 Applicability of generic wide area radio access standards to Vehicle-to-Infrastructure (V2I) communications 181
 - 8.4 Networking Standards for V2I Communications 185
 - 8.4.1 Non-IP networking technologies for critical messaging 185
 - 8.4.2 IP-based vehicular networking 186
 - 8.5 Summary 198
 - References 198

- 9 Simulating Cooperative Vehicle-to-Infrastructure Systems: A Multi-Aspect Assessment Tool Suite 203**
Gerdien Klunder, Isabel Wilmink and Bart van Arem
 - 9.1 Introduction on Design and Evaluation of Cooperative Systems 204
 - 9.2 Design Problems for Cooperative Systems 204
 - 9.3 SUMMITS Tool Suite and Multi-Aspect Assessment 205
 - 9.3.1 Multi-aspect assessment 205
 - 9.3.2 The SUMMITS Tool Suite 206
 - 9.3.3 Some practical aspects of the approach 207
 - 9.4 Integrated Full-Range Speed Assistant 208
 - 9.4.1 Modes and functions 208
 - 9.4.2 Scenarios 209
 - 9.4.3 IRSA controllers 209
 - 9.5 System Robustness – Simulations with a Multi-Agent Real-Time Simulator . 212
 - 9.5.1 Aims of the simulation 212

9.5.2	Implementation of IRSA in MARS	213
9.5.3	Evaluation of robustness of IRSA CACC controllers	215
9.5.4	Conclusions on the simulations with MARS	217
9.6	Traffic Flow Impacts – Simulations in the ITS Modeller	218
9.6.1	Aims of the simulations	218
9.6.2	Implementation of IRSA in the ITS modeller	219
9.6.3	Results for the ‘approaching a traffic jam’ scenario	221
9.6.4	Results for the ‘approaching a reduced speed limit zone’ scenario	222
9.6.5	Results for the ‘leaving the head of a queue’ scenario	223
9.6.6	Conclusions on the ITS modeller simulation results	224
9.7	Conclusions	224
	References	225
10	System Design and Proof-of-Concept Implementation of Seamless Handover Support for Communication-Based Train Control	227
	<i>Marc Emmelmann</i>	
10.1	Introduction	228
10.2	Fast Handover for CBTC using Wi-Fi	229
10.2.1	Requirements of Communications-Based Train Control for fast handover support	229
10.2.2	Taxonomy of handover phases	230
10.2.3	IEEE 802.11 fast handover support	231
10.2.4	Challenges of CBTC for Wi-Fi-based fast handover support	239
10.3	System Concept and Design	239
10.3.1	System architecture	240
10.3.2	MAC scheme	241
10.3.3	Predictive fast handover	242
10.4	Implementation	243
10.4.1	Methodology	243
10.4.2	Proof-of-concept demonstrator	244
10.5	Performance Evaluation	245
10.5.1	Metric design	245
10.5.2	Empirical evaluation	247
10.6	Conclusion	253
	References	253
11	New Technological Paradigms	257
	<i>Bernd Bochow</i>	
11.1	Evolution and Convergence of Vehicular Networks	258
11.2	Future Challenges	259
11.2.1	Handling network growth	259
11.2.2	Managing resources in ad hoc scenarios	260
11.2.3	Enabling interworking, integration and convergence	261
11.2.4	Providing integrated on-board and vicinity communications	261
11.3	New Paradigms	262
11.3.1	RF LoS obstruction due to other vehicles in close vicinity	263

- 11.3.2 Increased demand for accuracy of positioning and time synchronization 263
- 11.3.3 Optimization of message RTT 263
- 11.3.4 Gaining and distributing knowledge on topology and resource availability in temporal, spatial and spectral dimensions 264
- 11.3.5 Efficient collaboration and cooperation in resource utilization 264
- 11.4 Outlook: the Role of Vehicular Networks in the Future Internet 265
- References 267

- Further Reading** **271**
- Acronyms and Abbreviations** **275**
- Subject Index** **285**

<http://www.pbookshop.com>

<http://www.pbookshop.com>