Intelligent Transportation Systems

AUTOMOTIVE INTERNETWORKING

Timo Kosch, Christoph Schroth,
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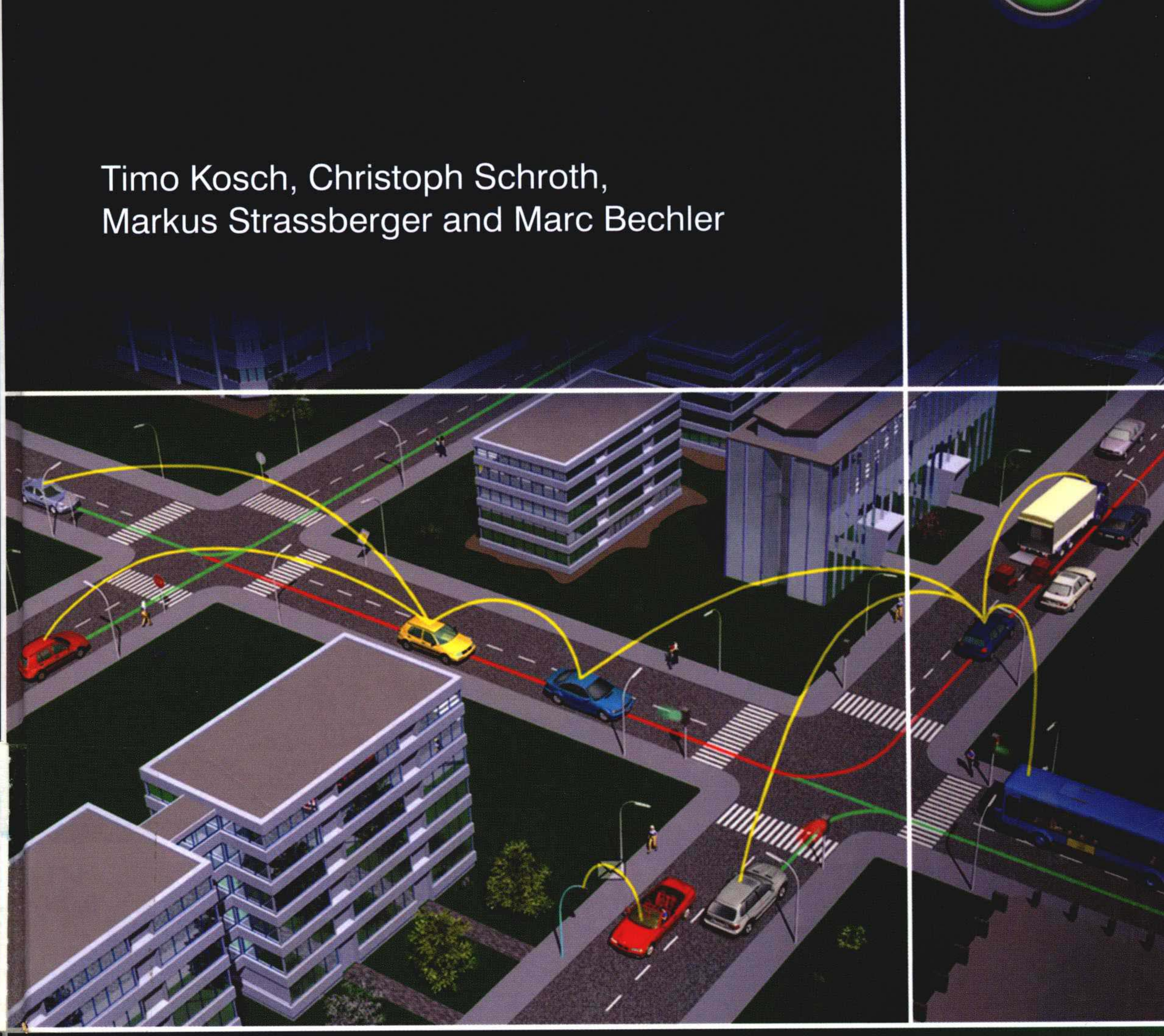

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This book introduces a range of new network and system technologies for vehicle safety, entertainment and comfort systems currently being researched and developed. In addition, the authors provide an insight into the background of technical developments, discussing the potential benefits, costs and risks. Furthermore, the book discusses the concepts related to the application of vehicle-to-vehicle and vehicle-to-infrastructure communications, offering in-depth explanations of the new applications, network and system technologies, which are valuable for the engineer developing such systems and the research expert alike.

The book covers all aspects from distributed information handling, situation assessment, security, privacy, system management up to algorithms for driver assistance and vehicle control systems. Beyond technology, the book also addresses economic, organisational and political challenges. Often overlooked, their influence on the success of automotive internetworking is just as important.

Key Features:

- Presents a comprehensive top-down approach to the newly evolving car-to-X communications networking
- Provides a broad overview of all relevant C2X communication topics
- Written by well known experts in the field
- Predicts the outlook of the evolvement of inter-vehicle communications in the next decades
- Includes illustrations and high-level technical sketches of application domains and photographs, 3D renderings and professional graphical sketches of current prototypes

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Preface

Tow Stories

Tug-of-war (or towing) games are known in almost every country of the world – in fact, a tug-of-war competition is an ancient team sport, which is still very popular today. In Germany, we have the famous phrase 'den Karren aus dem Dreck ziehen', which literally means to 'tow' something ('a trolley') out of a precarious situation towards a successful destination. The introduction of a new technology into the market can be considered as a *tow story*, too. This is in particular true for cooperative transportation systems based on AutoNets, which may be seen as a tow story of three parts:

1. In the first part of the story, a heavy trolley called 'AutoNet' needs to be defined and constructed.
2. In the main section, this trolley must be towed along a long and challenging path with several hurdles.
3. At the happy end of the tow story, the trolley passes the market introduction successfully.

Interestingly, the early days of cooperative transportation systems already outlined the correlation to tow stories. CHAUFFEUR, one of the first and pathbreaking projects in this field, developed a 'tow bar, which links two trucks electronically'.[1] Whereas the market introduction of a new technology is new to the stakeholders, the rules for a tow story are well understood by the players. Let's see what we can learn from these experiences for our challenging AutoNet tow story:

- Since the AutoNet trolley is pretty heavy, it is not possible for single keyplayers to manage the task. Instead, lots of manpower, expertise and suitable equipment are required to construct the AutoNet trolley and to get it moving. Moreover, a robust tow is essential, which will not break; and all players have to be convinced in the robustness and solidity of the tow.
- Obviously, all players have to push the tow as hard as possible. Otherwise, the movement of the AutoNet trolley will stop immediately. However, physics also teaches us that pure strength is only half the truth: in order to maximise the overall strength, all force vectors have to point (and to tow) in the same direction. Of course, this direction must be defined and agreed among the players in advance.

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[1] Quoted from http://cordis.europa.eu/telematics/tap_transport/research/projects/chauffeur.html.

- We must not forget that pulling a tow also requires a good portion of skill and interaction rules. Otherwise, it may become inconvenient for players. For example, on sloping roads the players have to cooperate in a fair and foreseeable way to avoid the event that the tow winds around the neck of some players. This is often painful – and may even be dangerous – for the respective players.

Tow stories are also useful for writing a book. It is a hard work to tow a book trolley towards the successful publication of the book. Since the book trolley is also pretty heavy, it is impossible for the authors to tow the trolley towards successful completion without the valuable support and the excellent contribution of many other players. We want to thank all supporters that directly and indirectly helped and supported (and motivated) us during the writing and finalisation process. We are very happy about this great support; their contributions definitively helped to improve the quality of this book, which is one of the most important preconditions for a successful publication. Unfortunately, listing all of the contributors would be difficult: we had a lot of supporters, and we will likely and unintentionally forget some of them. So we prepared another 'towing game': you will find all of our supporters by towing together the letters in the following letter grid. Have fun! :-)

Timo Kosch, Christoph Schroth, Markus Strassberger and Marc Bechler

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D F G C L I N K O F F R E T T A T S H C M H I S O F R Y G W Q
Q A B G M R E I E S E C A S T R A K A V G I K L M P W E T B S
A R D C T F K E M S L O R E L H C E B M R B Y D C V L T S W S
Z E H I D R F H K L T N N U T T U X G C A W E K D H W B N E A
N O S R E H P C M C A E S C H D C C N H F E L O L V J Z M Y Y
E G I U N Z E S E L E O I H O R S A H E F Y L L E U O H C R S
E I S J I M T O E T C K U N U U C E R O D L I L F V A E Y G E
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O E A E I I A U L S M A H W C C R T M B T R Z O H O E C O X L
P S M K O N L F F U J I S O A Y O G A S Z G N E C I H T E Y M
Y S Y N T R A M J S L H R M R I H M H R E D E R S R L K R B B
D Q E K E S T E I N B E R G S N S C P X R J R H O O L O E M E
F R R P P E U K A F P G B P E O T S C A K E S T N I U R G K D
G L F Y R M S T R A S S B E R G E R S O N A H I E C E S I H R
B L F A I N D M U B R E N M A C L E R S E I B I V N M C E I J
R O O L C H H R O E L L E Q R E L E A S M V E S N A Y H W R U
O K R C F F P E W S A L K I N H Q Y G D B E I S D D R H H T H
I F P R R N S T P I N F I W S E V E M N R Y R R W V F T C T G
Z M D A E L D I E T S M M E R L I N H O A B A R E R E P S E V
G L I B N U F C S C H S R Z V F I H C S M M O E L L I M B U S
R A S S H A R M A M L O H B O F U R E J F N T U H J R S C I A
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List of Abbreviations

AC	Access Category
ACC	Adaptive Cruise Control
ACID/ACM	Application Class Identifier / Application Context Mark
ACK	Acknowledgement
ADAS	Advanced Driver Assistance Systems
AHP	Analytic Hierarchy Process
AIFS	Arbitration Inter-Frame Space
AKTIV	Adaptive und kooperative Technologien für den intelligenten Verkehr (Adaptive and Cooperative Technologies for the Intelligent Traffic)
ANSim	Ad Hoc Network Simulator
AODV	Ad Hoc On Demand Distance Vector
AP	Access Point
API	Application Programming Interface
ARQ	Automatic Request and Repeat
ASTM	American Society for Testing and Materials
ATCP	Ad hoc Transmission Control Protocol
AUTOSAR	Automotive Open Systems Architecture
BC	Backoff Counter
BLADE	Business Models, Legal Aspects, and Deployment
BMBF	Bundesministerium für Bildung und Forschung (German Federal Ministry of Education and Research)
BMWi	Bundesministerium für Wirtschaft und Technologie (German Federal Ministry of Economics and Technology)
BSA	Basic Set of Applications
BSM	Basic Safety Message
BSS	Basic Service Set
C2C-CC	Car-to-Car Communication Consortium
CA	Certificate Authority
CAL	Communication Adaptation Layer
CALM	Communications Access for Land Mobiles
CAM	Cooperative Awareness Message
CAN	Controller Area Network
CAPEX	Capital Expenditures

CCH	Control Channel
CCMP	Counter Mode with Cipher Block Chaining Message Authentication Code Protocol
CCoA	Co-Located Care-Of Address
CEN	Comité Européen de Normalisation (European Committee for Standardisation)
CEPT	Conference of European Postal & Telecommunications Administrations
CI	Communication Interface
CIDR	Classless Inter-Domain Routing
CIMAE	CI Management Adaptation Entity
CN	Correspondent Node
CoA	Care-of Address
COM2REACT	Cooperative Communication System to Realise Enhanced Safety and Efficiency in European Road Transport
COMCAR	Communication and Mobility by Cellular Advanced Radio
COOPERS	Cooperative Systems for Intelligent Road Safety
COTS	Components Off-The-Shelf
CRL	Certificate Revocation List
CSMA/CA	Carrier Sense Medium Access / Collision Avoidance
CVIS	Cooperative Vehicle-Infrastructure Systems
CW or CWND	Contention Window
DAB	Digital Audio Broadcast
DACL	Discretionary Access Control List
DCF	Distributed Coordination Function
DDT	Distance Defer Transmission
DENM	Decentralised Environment Notification Message
D-FPAV	Distributed Fair Transmit Power Adjustment for Vehicular Networks
DHCP	Dynamic Host Configuration Protocol
DIFS	Distributed Coordination Function Inter-Frame Space
DMB	Digital Multimedia Broadcast
DoS	Denial of Service
DoT	Department of Transportation (USA)
DRiVE	Dynamic Radio for IP Services in Vehicular Environments
DRP	Distributed Revocation Protocol
DSDV	Destination Sequenced Distance Vector
DSR	Dynamic Source Routing
DSRC	Dedicated Short Range Communication
DSSS	Direct Sequence Spread Spectrum
DVB	Digital Video Broadcast
DVDE	Distributed Vehicle Density Estimation
EASIS	Electronic Architecture & System Engineering for Integrated Safety Systems
EC	European Commission
ECC	Electronic Communications Committee
ECC	Elliptic Curve Cryptography
ECDSA	Elliptic Curve Digital Signature Algorithm

ECN	Explicit Congestion Notification
ECU	Electronic Control Unit
EDCA	Enhanced Distributed Channel Access (of IEEE 802.11e)
EDCF	Extended Distributed Coordination Function
EDGE	Enhanced Data Rates for GSM Evolution
EDR	Event Data Recorder
EFCD	Enhanced Floating Car Data
ERM	Electromagnetic compatibility and Radio spectrum Matters
ESA	Enhanced Set of Applications
ESP	Electronic Stability Program
ETC	Electronic Toll Collection
ETSI	European Telecommunications Standards Institute
EU	European Union
FA	Foreign Agent
FACH	Forware Link Access Channel
FCC	Federal Communications Commission (USA)
FCD	Floating Car Data
FCFS	First Come First Served
FEC	Forward Error Correction
FHWA	Federal Highway Administration (USA, DoT)
FIFO	First-In First-Out
FOT	Field Operational Test
FS	Fixed Service
GNSS	Global Navigation Satellite System
GIDAS	German In-Depth Accident Study
GloMoSim	Global Mobile Information Systems Simulation
GLOSA	Green Light Optimal Speed Advisory
GPRS	General Packet Radio Service
GPS	Global Positioning System
GPSR	Greedy Perimeter Stateless Routing
GSM	Global System for Mobile Communications
GST	Global System for Telematics
HA	Home Agent
HMAC	Hashed Message Authentication Code
HMI	Human–Machine Interface
HSCSD	High Speed Circuit Switched Data
HSM	Hardware Security Module
HSPA	High Speed Packet Access (in UMTS networks)
HSDPA	High Speed Downlink Packet Access
HSUPA	High Speed Uplink Packet Access
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
I-BIA	Intelligent Broadcast with Implicit Acknowledgement
ICMP	Internet Control Message Protocol
ICRW	Intersection Collision Risk Warning
ICT	Information and Communication Technology

ICTSB	Information and Communication Technology Standards Board
ID	Identification
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IEEE-SA	IEEE Standards Association
IETF	Internet Engineering Task Force
IFS	Insurance and Financial Services
INVENT	Intelligenter Verkehr und nutzergerechte Technik (Intelligent Road Traffic and User-Friendly Technologies)
IP	Internet Protocol
IPR	Intellectual Property Rights
IPSec	Internet Protocol Security
IPv6	Internet Protocol version 6
ISM Band	Industrial, Scientific and Medical Band
ISO	International Organisation for Standardisation
IST	Information Society Technology
ITS	Intelligent Transportation Systems
ITSSG	Intelligent Transport Standards Steering Group
ITU	International Telecommunication Union
IVHW	Inter-Vehicle Hazard Warning
IVI	In-Vehicle Infotainment
LAN	Local Area Network
LCRW	Longitudinal Collision Risk Warning
LDM	Local Dynamic Map
LDW	Local Danger Warning
LIN	Local Interconnect Network
LLC	Logical Link Control
LLCert	Long-Life Certificate
LOS	Line-of-Sight
LTE	Long Term Evolution
M2M	Machine-to-Machine
MAC	Medium Access Control
MAIL	Media Adapted Interface Layer
MAN	Metropolitan Area Network
MBMS	Multimedia Broadcast Multicast Service
MCTP	MOCCA Transport Protocol
MEXT	Mobility Extensions for IPv6
MFR	Most Forward Progress within Radius
MIB	Management Information Base
MN	Mobile Node
MNO	Mobile Network Operator
MNS	Mobile Network Suppliers
MOCCA	Mobile Communication Architecture
MONAMI6	Mobile Nodes and Multiple Interfaces in IPv6
MOST	Media Oriented Systems Transport

MoTiV	Mobilität und Transport im intermodalen Verkehr (Mobility and Transportation in Inter-Modal Road Traffic Scenarios)
NAT	Network Address Translation
NEMO	Network Mobility
NFC	Near-Field Communications
NFP	Nearest with Forward Progress
NHTSA	National Highway Traffic Safety Administration (USA, DoT)
NOW	Network on Wheels
ns2	Network Simulator 2
OBU	On-Board Unit
ODAM	Optimised Dissemination of Alarm Messages
OEM	Original Equipment Manufacturer
OFDM	Orthogonal Frequency Division Multiplexing
OMG	Object Management Group
OPEX	Operational Expenditures
OSEK	Offene Systeme und deren Schnittstellen für die Elektronik im Kraftfahrzeug (Open Systems and the Corresponding Interfaces for Automotive Electronics)
OSGi	Open Services Gateway Initiative
OSI	Open Systems Interconnection
OTCL	Object Tool Command Language
PA	Physical Attack
PAN	Personal Area Network
PATH	Partners for Advanced Traffic Highways
PCF	Point Coordination Function
PDU	Protocol Data Unit
PEP	Performance-Enhancing Proxy
PF	Performance Factor (of IEEE 802.11e)
PKI	Public Key Infrastructure
PND	Personal Navigation Device
PSK	Pre-Shared Key
QoS	Quality of Service
RACH	Random Access Channel
RADIUS	Remote Authentication Dial In User Service
REAR	Reliable and Efficient Alarm Message Routing
RCCRL	Revocation by Compressed Certificate Revocation List
RFC	Request for Comment
RFID	Radio Frequency Identification
RSA	Rivest, Shamir, Adleman
RTO	Retransmission Timeout
RTPD	Revocation of Tamper-Proofed Device
RTS/CTS	Request To Send / Clear to Send
RTT	Round Trip Time
RTTT	Road Transport and Traffic Telematics
SAE	Society of Automotive Engineers
SAP	Service Access Point

SBA	Smart Broadcast Algorithm
SCH	Service Channel
SDK	Software Development Kit
SDO	Standards Development Organisation
SIFS	Short Interframe Space
simTD	Sichere und intelligente Mobilität, Testfeld Deutschland (Safe and Intelligent Mobility, Test Trial Germany)
SLCert	Short-Life Certificates
SOA	Service-Oriented Architecture
SOAP	Simple Object Access Protocol
SPAV	Segment-based Power Adjustment
SPAT	Signal Phase and Timing
SRDoc	System Reference Document
SSL	Secure Socket Layer
ssthresh	Slow Start Threshold
SUMO	Simulation of Urban Mobility
TC	Technical Committee
TC	Traffic Class
TCL	Tool Command Language
TCP	Transmission Control Protocol
TG	Technical Group
TISA	Traveller Information Services Association
TLS	Transport Layer Security
TMC	Traffic Message Channel or Traffic Management Centre
TORA	Temporally Ordered Routing Algorithm
TPC	Transmitter Power Control
TPD	Tamper-Proof Device
TPEG	Transport Protocol Experts Group
TPM	Trusted Platform Module
TRADE	Track Detection
TRRS	Time Reservation-based Relay Node Selecting Algorithm
TTP	Trusted Third Party
UDDI	Universal Description Discovery and Integration
UDP	User Datagram Protocol
UI	User Interface
UMB	Urban Multi-Hop Protocol
UML	Unified Modeling Language
UMTS	Universal Mobile Telecommunications System
UTC	Universal Time Coordinated
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
VANET	Vehicular Ad-Hoc Network
VDX	Vehicle Distributed Executive
VII	Vehicle Infrastructure Integration
VIN	Vehicle Identificaion Number
VMT	Vehicle Miles Travelled

VPN	Virtual Private Network
VSC	Vehicle Safety Communications
VTS	Vehicle Traffic Simulator
WA	Wireless Attack
WAP	Wireless Application Protocol
WAVE	Wireless Access in Vehicular Environments
WBSS	WAVE Basic Service Set
WG	Working Group
WHO	World Health Organisation
WiMAX	Worldwide Interoperability for Microwave Access
WLAN	Wireless Local Area Network
WME	WAVE Management Entitiy
WPA	Wi-Fi Protected Access
WRAP	Wireless Robust Authenticated Protocol
WS	Wireless Simulator
WSDL	Web Services Description Language
WSM	WAVE Service Management
WSMP	WAVE Short Message Protocol
XFCD	Extended Floating Car Data
XML	Extensible Markup Language
XTR	Efficient and Compact Subgroup Trace Representation

Contents