Automotive Ethernet

Do you need to get up to date with the world's most popular networking technology? With this resource you will discover everything you need to know about Ethernet and its implementation in the automotive industry.

Enhance your technical understanding and better inform your decision making process so that you can experience the benefits of Ethernet implementation. From new market opportunities, to lower costs, and less complex processes, this is the first book to provide a comprehensive overview of Automotive Ethernet. Covering electromagnetic requirements and Physical Layer technologies, Quality of Service, the use of VLANs, IP, and Service Discovery, as well as network architecture and testing, this unique and comprehensive resource is a must have, whether you are a professional in the automotive industry, or an academic who needs a detailed overview of this revolutionary technology and its historical background.

Kirsten Matheus is a communications engineer who is currently responsible for establishing Ethernet-based communication in the industry. She also initiated and chaired the OPEN Alliance and helped establish the IEEE 802.3 Reduced Twisted Pair Gigabit Ethernet (RTPGE, 1000BASE-T1) working group.

Thomas Königseder is an electronics engineer and Group Manager for Communications Technologies at BMW. He was responsible for launching the first ever serial car with an Ethernet connection.

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Automotive Ethernet

KIRSTEN MATHEUS AND THOMAS KÖNIGSEDER
BMW AG, München

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Preface

On 11 November 2013, I [Kirsten Matheus] attended a celebration of 40 years since the invention of Ethernet at an IEEE 802 plenary meeting. During the celebration Robert Metcalfe, David Boggs, Ronald Crane, and Geoff Thompson were honoured as the pioneers of Ethernet. If I had to name the people without whom Automotive Ethernet would not have happened, I would name Thomas Königseder, technical expert at BMW and co-author of this book, and Neven Pischl, EMC expert at Broadcom.

It all started in 2004, when Thomas received the responsibility for speeding up the software flash process for BMW cars. With the CAN interface used at the time, flashing the 1 Gbyte of data anticipated for 2008 would have required 16 hours to complete. After careful evaluation, Thomas chose and enabled the use of standard 100BASE-TX Ethernet for this purpose. Thus in 2008 the first serial car with an Ethernet interface, a BMW 7-series, was introduced to the world.

This was only a small beginning though. The problem was the electromagnetic (i.e. EMC) properties of standard 100BASE-TX Ethernet were not good. So the technology was useable with cost competitive unshielded cables only when the car was stationary in the garage. To use 100BASE-TX when the car was moving would have required shielding the cables and that was too expensive.

Yet, Thomas was taken with the effectiveness of Ethernet-based communication and therefore investigated ways to use 100BASE-TX over unshielded cables. He identified the problem, but could not solve it. So in 2007 he contacted various well-established Ethernet semiconductor suppliers to work with him on a solution. Only Broadcom responded positively and engineers from both companies evaluated the BMW 100BASE-TX Ethernet EMC measurements. Then, in January 2008 it happened. BMW performed EMC measurements with boards the Broadcom engineer Neven Pischl had optimized using a 100 Mbps Ethernet PHY variant originally developed by Broadcom for Ethernet in the First Mile and which Broadcom engineers had further adapted for automotive application. The very first measurements ever performed at a car manufacturer with this technology were well below the limit lines and yielded better EMC performance results than even the existing FlexRay!

This was when Automotive Ethernet was born. Without having had this technology available at the right time, without proving that 100 Mbps could be transmitted over Unshielded Twisted Pair (UTP) cables in the harsh automotive EMC environment, none of all the other exciting, complementary, futuristic, and otherwise useful developments in the field would have happened. BMW would likely be using Media Oriented Systems

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Transport (MOST) 150 and be working on the next speed grade of MOST together with the rest of the industry.

Naturally, from the discovery of a solution in 2008 to the first ever introduction of UTP Ethernet in a serial car, a BMW X5, in 2013, and to the establishment of Automotive Ethernet in the industry was and still is a long process. Thomas and I would therefore like to thank all those who helped to make this happen, and those who are today fervently preparing the bright future Ethernet has in Automotive, inside and outside of BMW, with a special mention for Stefan Singer (Freescale), who among other things established the first contact between BMW and Broadcom. Using Ethernet for in-car networking is a revolution, and it is an unparalleled experience to be able to participate in it.

This book explains the history of Automotive Ethernet in more detail, and also how Automotive Ethernet can technically be realized. We would like to thank all those who supported us with know-how and feedback in the process of writing this book. First, Thilo Streichert (Daimler), who made it his task to review it all, and who saved the readers from some of the blindness that occurs to authors having worked on a particular section for too long. Then, in alphabetical order, we thank Christoph Arndt (FH Deggendorf), Jürgen Bos (Ericsson, EPO), Karl Budweiser (TU München), Steve Carlson (HSPdesign), Bob Grow (RMG Consulting), Mickael Guilcher (BMW), Robert von Häfen (BMW), Florian Hartwich (BOSCH), Thomas Hogenmüller (BOSCH), Michael Johas Teener (Broadcom), Michael Kaindl (BMW), Oliver Kalweit (BMW), Ramona Kerscher (FH Deggendorf), Matthias Kessler (ESR Labs), Max Kicherer (BMW), Yong Kim (Broadcom), Rick Kreifeld (Harman), Thomas Lindenkreuz (BOSCH), Thomas Lindner (BMW), Stefan Schneele (EADS), Mehmet Tazebay (Broadcom), Lars Völker (BMW), Ludwig Winkel (Siemens), and Helge Zinner (Continental). Last, but not least, we would like to thank BMW for supporting our work for the book.

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Abbreviations

#	number of
1PPoDL	1 Pair Power over Data Line
2D	Two dimensional
3D	Three dimensional
4D	Four dimensional
AAN	Automotive Area Network
ACK	Acknowledgement
ACR-F	Attenuation to Crosstalk Ratio at Far end
ACR-N	Attenuation to Crosstalk Ratio at Near end
ADAS	Advanced Driver Assist System
ADC or A/D	Analog to Digital Converter
ADSL	Asynchronous Digital Subscriber Line
AEC	Automotive Electronics Council
AFDX	Avionics Full-Duplex Switched Ethernet
AFEXT	Alien Far End Crosstalk
AGC	Adaptive Gain Control
AIDA	AutomatisierungsInitiative der Deutschen Automobilhersteller (English: Automation Initiative of German Automobile Manufacturers)
ALOHA	Hawaiian greeting, the name of the multiple user access method developed at the University of Hawaii
AMIC	Automotive Multimedia Interface Corporation
Amp./AMP	Amplifier
ANEXT	Alien Near End Crosstalk
ANSI	American National Standards Institute
API	Application Programming Interface
APIX	Automotive PIXel link
ARINC	Aeronautical Radio, Inc., a company founded in 1929, which today, among other things, publishes communication standards for the aerospace/aviation industry
ARP	Address Resolution Protocol
ARPANET	Advanced Research Projects Agency Network
ASN	Avionics Systems Network
ATM	Asynchronous Transfer Mode, a telecommunications protocol used in networking

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AUTOSAR	AUTomotive Open System ARchitecture, organization for the development of standards for software development in automotive
AV	Audio Video
AVB	Audio Video Bridging, refers to a set of standards published in the IEEE
AVBgen1	First generation of IEEE AVB standards
AVBgen2	Second generation of IEEE AVB standards, renamed TSN
AVBTP	AVB Transport Protocol based on IEEE 1722
AVnu	Includes the AV for Audio Video and also means road in Creole [1]
AVS	Audio Video Source
AXE	Name of Ericsson's digital switch product line
B	billion
BAG	Bandwidth Allocation Gap
BCI	Bulk Current Injection
BLW	BaseLine Wonder correction
BM	Bus Minus (FlexRay terminology)
BMCA	Best Master Clock selection Algorithm
BP	Bus Plus (FlexRay terminology)
BPDU	Bridge Protocol Data Units
BSD	Berkeley Standard Distribution or Berkeley Software Distribution
C2C	Car-to-Car (communication)
C2X	Car-to-anything (communication)
CAGR	Compound Annual Growth Rate; $\text{CAGR} = (\text{Volume } t_2/\text{Volume } t_1)^{(1/(t_2-t_1))} - 1$
CAN	Controller Area Network
CC	Communication Controller
CCITT	Comité Consultatif International Téléphonique et Télégraphique, renamed ITU-T in 1993
CD	Compact Disc
CDM	Charged Device Model
CE	Consumer Electronics or Carrier Ethernet
CFI	Call For Interest
CIDR	Classless Inter-Domain Routing
CISPR	Comité International Spécial des Perturbations Radioélectriques
CMC	Common Mode Choke
CML	Current Mode Logic
COTS	Commercial-Off-The-Shelf
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check, a form of channel coding used to detect (and sometimes correct) errors in a transmission
CSMA/CD	Carrier Sense Multiple Access with Collision Detection
CSN	Coordinated Shared Network
D^2B	Domestic Digital Bus
DAC or D/A	Digital to Analog Converter
DAS	Driver Assist Systems or Driver Assist

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DC	Direct Current
DEI	Drop Eligible Indicator
DFE	Decision Feedback Equalizer
DHCP	Dynamic Host Configuration Protocol
DIX	DEC Intel XeroX
DLL	Data Link Layer
DLNA	Digital Living Network Alliance
DMA	Direct Memory Access
DMLT	Distinguished Minimum Latency Traffic
DNS	Domain Name System
DRM	Digital Rights Management
DSP	Digital Signal Processor
DSQ 128	Double Square constellation, 2 times 16 discrete levels of PAM16 mapped onto a two-dimensional checker board
EADS	European Aeronautic Defence and Space Company, Airbus is a division of EADS
ECU	Electronic Control Unit
EE or E/E	Electric Electronic
EEE	Energy Efficient Ethernet
EFM	Ethernet in the First Mile (IEEE 802.3ah)
EIA	Electronic Industries Alliance
ELFR	Early Life Failure Rate
ELTCTL	Equal Level Transverse Conversion Transfer Loss
EMC	ElectroMagnetic Compatibility
EMD	Electronic Master Device
EME	ElectroMagnetic Emissions
EMI	ElectroMagnetic Immunity (in other documents sometimes also used for ElectroMagnetic Interference!)
EMS	ElectroMagnetic Susceptibility, more common: EMC immunity
EPO	European Patent Office
EPON	Ethernet Passive Optical Network (part of EFM)
ESD	ElectroStatic Discharge
Eth.	Ethernet
Euro NCAP	European New Car Assessment Programme
EWSD	Elektronisches Wählsystem Digital (English: Electronic Digital Switching System/Electronic World Switch Digital)
FBAS	FarbBildAustastSynchron signal (English: CVBS, Color, Video, Blanking, and Synchronous Signal)
FCC	Federal Communications Commission
FCDM	Field induced Charge Device Model
FCS	Frame Check Sequence
FD CAN	CAN with Flexible Data rate
FEC	Forward Error Correction
FFE	Feed Forward Equalizer

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FIFO	First In First Out
FlexRay	A serial, deterministic and fault tolerant fieldbus for automotive use
FOT	Fiber Optical Transmitter
FPD	Flat Panel Display
FRAND	Fair, Reasonable and Non-Discriminatory (the European equivalent of RAND)
FTZ	Forschungs- und Transfer Zentrum (English: Research and Transfer Center), part of the University of Applied Science in Zwickau, Germany
GB	Giga Bytes
Gbps	Giga bit per second
GDP	Gross Domestic Product
GENIVI	A word construct taken from Geneva, the international city of peace, in which apparently the concept of GENIVI was publically presented for the first time, and In-Vehicle Infotainment [2]
GMII	Gigabit Media Independent Interface
GND	GrouND
GOF	Glass Optical Fiber
GPS	Global Positioning System
gPTP	generalized Precision Time Protocol
h	hour
H.264	Also MPEG-4 Part 10 or Advanced Video Coding, video compression standard of ITU-T
HBM	Human Body Model
HD	High Definition
HDCP	High-bandwidth Digital Content Protection
HDMI	High-Definition Multimedia Interface
HE	High End
hi-fi	High Fidelity, term used to refer to high-quality reproduction of sound in the home, invented in 1927 [3]
HMI	Human–Machine Interface
HPF	High Pass Filter
HS CAN	High-Speed CAN
HSE	High-Speed Ethernet, Industrial Ethernet variant of the Fieldbus Foundation
HSFZ	High-Speed Fahrzeug Zugang (High-Speed Car Access)
HU	Head Unit, main infotainment unit inside the car (former radio)
I^2C	Inter-Integrated Circuit, referred to also as I-two-C or IIC
I^2S	Inter-IC Sound, Integrated Interchip Sound, or IIS
IANA	Internet Assigned Numbers Authority
IC	Integrated Circuit
ICMP	Internet Control Message Protocol
ID	IDentifier, IDentification
IDL	Interface Definition Language or Interface Description Language
IEC	International Electrotechnical Commission

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IEEE	Institute of Electrical and Electronics Engineers
IEEE-RA	IEEE Registration Authority
IEEE SA	IEEE Standards Association
IET	Interspersing Express Traffic
IETF	Internet Engineering Task Force
IFE	In-Flight Entertainment
IGMP	Internet Group Management Protocol
IL	Insertion Loss or Attenuation
Infotainment	INFOrmation and entertAINMENT
INIC	Intelligent Network Interface Controller
I/O	Input/Output
IP	Industrial Protocol or Internet Protocol
IPC	InterProcess Communication
IP(R)	Intellectual Property (Rights)
IPsec	Internet Protocol SECurity
ISO	International Organization for Standardization
ITU-T	International Telecommunication Union – Telecommunications standardization sector
JASPAR	Japan Automotive Software Platform and ARchitecture
JPEG	Joint Photographic Experts Group (standardized in ISO/IEC 10918–1, CCITT Recommendation T.81), describes different methods for picture compression
kbps	kilo bit per second
K-Line	Name for a single-ended, RS-232 similar technology standardized in ISO 9141–2
LAN	Local Area Network
LDPC	Low Density Parity Check
LIN	Local Interconnect Network
LLC	Logical Link Control
LPF	Low Pass Filter
LPI	Low Power Idle
LS CAN	Low-Speed CAN
LVDS	Low-Voltage Differential Signaling
MAAP	MAC Address Acquisition Protocol
MAC	Media Access Control
MB	Mega Bytes
Mbps	Mega bit per second
MEF	Metro Ethernet Forum
MHL	Mobile High-definition Link
MIB	Management Information Base
MIDI	Musical Instrument Digital Interface manufacturers' association
min	minutes
Mio	millions
MJPEG	Motion JPEG

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MLB	Media Local Bus (specified for MOST)
MM	Machine Model
MMRP	Multiple MAC Registration Protocol
MOST	Media Oriented Systems Transport
MOST Co	MOST Corporation
MP3	MPEG-1 Audio Layer III (MPEG-1 Part 3) or MPEG-2 Audio Layer III (MPEG-2 Part 3)
MPEG	Moving Picture Experts Group, set standards for audio/video compression and transmission
MPEG2-TS	MPEG No. 2-Transport Stream
MPLS	Multi Protocol Label Switching
MQS	Micro Quadlock System (type of connector)
Msps	Mega symbols per second, equals MBaud
MSRP	Multiple Stream Reservation Protocol
MVRP	Multiple VLAN Registration Protocol
µC	Micro-Controller
n/a	not available or not applicable
NACK	Packet has not been received as expected (Negative ACK)
NAT	Network Address Translation
NC	Numerically Controlled
NEXT	Near End Crosstalk
NIC	Network Interface Controller
NM	Network Management
NRZ	Non Return to Zero, two-level signaling often used for optical transmission
ns	nanoseconds
OABR	Open Alliance BroadR-Reach, sometimes also referred to as UTSP Ethernet or simply as BroadR-Reach
OAM	Operation, Administration, Management
OBD	OnBoard Diagnostic
OEM	Original Equipment Manufacturer, in the automotive industry often used as a synonym for car manufacturer
OPEN	One Pair EtherNet
OS	Operating System
OSEK	"Offene Systeme und deren Schnittstellen für die Elektronik im Kraftfahrzeug" (English: Open systems and their interfaces for electronics in automobiles)
OSI	Open Systems Interconnection
P2MP	Point-to-Multipoint (refers to a form of sharing the medium)
P2P	Point-to-Point (can, in another context, also mean Peer-to-Peer)
PAM	Pulse Amplitude Modulation
PAMx	x-level Pulse Amplitude Modulation
PAN	Personal Area Network
PC	Personal Computer

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PCB	Printed Circuit Board
PCS	Physical Coding Sublayer
PHY	Physical Layer, refers to the physical signaling and media, layer 1 of the ISO/OSI layering model
PICS	Protocol Implementation Conformance Statement
PLC	Programmable Logic Controller
PLL	Phase Lock Loop
PMA	Physical Medium Access
PoDL	Power over Data Line, used for transmission of power over an (Ethernet) data line independent from the number of pairs needed
PoE	Power-over-Ethernet, note that this refers directly to the implementation described in IEEE 802.3af (which was later incorporated as clause 33 into the revision document IEEE 802.3–2005) and IEEE 802.3at focusing on the 2 pair 100BASE-TX Ethernet
POF	Polymeric/Plastic Optical Fiber
POSIX	Portable Operating System Interface
PPM	Parts Per Million, sometimes also called Defects Per Million (DPM)
PS-ACR-F	Power Sum Attenuation to Crosstalk Ratio at Far end
PS-ACR-N	Power Sum Attenuation to Crosstalk Ratio at Near end
PS-NEXT	Power Sum for Near End Crosstalk
PSAACRF	Power Sum for Alien Attenuation to Crosstalk Ratio at Far end
PSANEXT	Power Sum for Alien Near End Crosstalk
PSD	Power Spectral Density
PSTN	Public Switched Telephone Network
PTP	Precision Time Protocol
PTPv2	PTP version 2 (based on IEEE 802.1AS instead of on the older IEEE 1588, PTPv1)
QoS	Quality of Service
RAND	Reasonable and Non-Discriminatory
RARP	Reverse Address Resolution Protocol
RFC	Request For Comment
RFI	Radio Frequency Interference
RGB	Red Green Blue, analog video transmission based on transmitting one color per cable
RL	Return Loss or Echo
ROM	Read Only Memory
RPC	Remote Procedure Call
RS-232	A binary, serial interface first introduced by the EIA in 1962
RSE	Rear Seat Entertainment
RTP	Real-time Transport Protocol
RTPGE	Reduced Twisted Pair Gigabit Ethernet
Rx/RxD	Receiver Ingress
S-parameter	Scattering-parameter
SD	Service Discovery

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SD-DVCR	Standard Definition Digital Video Cassette Recorder
SDH	Synchronous Digital Hierarchy (technology for core telecommunications networks)
Semicond.	Semiconductor(s)
SFD	Start Frame Delimiter
SIG	Special Interest Group
SMTP	Simple Mail Transfer Protocol
SNR	Signal-to-Noise Ratio
SoC	System on Chip
SOME/IP	Scalable service-Oriented MiddlewarE over IP
SONET	Synchronous Optical NETworking (technology for core telecommunications networks)
SOP	Start Of Production
SR	Stream Reservation
SRP	Stream Reservation Protocol
SRR	Substitute Remote Request
SSO	Standard Setting Organization
STP	Shielded Twisted Pair or Spanning Tree Protocol
SUV	Service Utility Vehicle
SVS	Surround View System
SW	SoftWare
TC	Technical Committee
TCI	Tag Control Information
TCL	Transverse Conversion Loss
TCP	Transmission Control Protocol
TDM	Time Division Multiplexing, also used as a synonym for circuit-switched networks
TEM	Transversal ElectroMagnetic (wave)
TIA	Telecommunications Industry Association
TP	Twisted Pair
TSMC	Taiwan Semiconductor Manufacturing Company
TSN	Time Sensitive Networking
TTL	Time-To-Live
Tx/TxD	Transmitter Egress
UDP	User Datagram Protocol
UDS	Unified Diagnostic Services
Unix	Derived from Uniplexed Information and Computing Service (UNICS)
UPnP	Universal Plug and Play
USB	Universal Serial Bus
USP	Unique Selling Proposition, Unique Selling Point
UTP	Unshielded Twisted Pair
UTSP	Unshielded Twisted Single Pair, if combined with Ethernet, this often also refers to OABR
UWB	Ultra Wide Band, IEEE 802.15.4a

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VAN	Vehicle Area Network
VCIC	Video Communication Interface for Cameras
VDE	Verband Deutscher Elektrotechniker (English: Association for Electrical, Electronic & Information Technologies)
VID	VLAN Identifier
VIN	Vehicle Identification Number
VL	Virtual Link
VLAN	Virtual LAN
VLSM	Variable Length Subnet Mask
VoIP	Voice over IP
WAN	Wide Area Network
WiFi	A marketing name invented by the WiFi Alliance for IEEE 802.11 enabled WLAN products. WiFi is often synonymously used for WLAN [4]
WLAN	Wireless LAN
WPAN	Wireless PAN
WRAN	Wireless Regional Area Network

References

[1] R. Kreifeld, Unpublished email correspondence, 2013.
[2] GENIVI Alliance, "GENIVI FAQ," 22 July 2013. [Online]. Available: http://www.genivi.org/sites/default/files/GENIVI_FAQ_072213.pdf [Accessed 11 October 2013].
[3] Hartley Loudspeakers, "A Brief History," 2013. [Online]. Available: http://www.hartleyloudspeakers.com/new_page_1.htm [Accessed 30 October 2013].
[4] Wikipedia, "WiFi," 1 November 2013. [Online]. Available: http://en.wikipedia.org/wiki/Wi-Fi [Accessed 1 November 2013].

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Timeline

1965	AT&T installs the world's first electronic telephone switch (special purpose computer) in a local telephone exchange [1].
1968	Invention of Programmable Logic Controllers (PLCs) [2].
1969	AT&T employees at Bell Labs develop the operating system Unix, which eventually enabled distributed computing with remote procedure calls and the use of remote resources. For antitrust reasons AT&T was neither allowed to sell Unix nor permitted to keep it to itself. In consequence, they made it available to everyone interested [3].
7 April 1969	RFC 1 is published [4], discussing the host software for ARPANET's switching nodes. ARPANET represents one of the world's first operational packet switching networks [5].
29 October 1969	The first ARPANET link is established between University of California, Los Angeles and Stanford Research Institute [6].
3 November 1971	Publication of the first "UNIX Programmer's Manual" [7].
By 1973	Unix is recoded in C (it was first developed in (an) Assembly language). This greatly enhances Unix's portability to different hardware and further encourages its distribution [7].
22 May 1973	First documentation of Ethernet as an idea in a memo from Robert Metcalfe at Xerox PARC [8]. At that time Xerox PARC was selling the first personal computer workstations (called "Xerox Alto") and had invented the first laser printers [9]. Metcalfe was working on a solution for data transmission between these products and the early Internet.
October 1973	Unix is presented publically to the Fourth Association for Computer Machinery on Operating System Principles [3].
11 November 1973	First Xerox internal demonstration of Ethernet [8].
1973	The International Electrotechnical Commission (IEC) creates a technical committee (TC77) to specifically handle questions of electromagnetic compatibility [10].
December 1974	Release of the "Specification of Internet Transmission Control Protocol (TCP)," RFC 675, initiated by the Defense Advanced Research Projects Agency (DARPA), and influenced by early

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	networking protocols from Xerox PARC and refined by the Networking Research Group of the University of Stanford [11].
31 March 1975	Xerox files a patent application on "Ethernet" naming Robert M. Metcalfe, David R. Boggs, Charles P. Thacker, and Butler W. Lampson as inventors [12].
1975	Honeywell and Yokogawa introduce the first distributed computer control systems for industrial automation [13].
July 1976	First paper published on Ethernet [14].
1977	The ISO forms a committee on Open System Interconnection (OSI) [15]. Somewhat later a group from Honeywell Information Systems presents their seven layer model to the ISO/OSI group [16].
9 March 1978	The Computer System Research Group of the University of California Berkeley releases its first Unix derivative, the Berkeley Software Distribution (BSD) [17].
1 April 1978	ARINC publishes the first ARINC 429 communication standard for avionic equipment [18].
June 1979	ISO publishes the OSI layering model [16].
4 June 1979	Metcalfe founds 3COM to build Ethernet competitive products and convinces DEC, Intel, and Xerox (referred to as DIX) to use and promote Ethernet as a standard for their products [8, 19].
1979–1982	Following 3COM, several start-up companies are founded to build Ethernet products. The most successful ones in the mid 80s are Ungermann-Bass (U-B), Interlan, Bridge Communications, and Excelan [19].
February 1980	IEEE starts 802 project to standardize LANs [19].
May 1980	The DIX group joins the IEEE 802 project and offers Ethernet for adoption while still working on it [19].
29 August 1980	The User Datagram Protocol (UDP) is published as RFC 768 [20].
30 September 1980	Publication of the first version of the so-called "DIX Standard" (from DEC/Intel/XeroX) on Ethernet. Running at 2.94 Mb/s it is able to support 256 devices [21].
December 1980	The IEEE 802 LAN effort is split into three groups: 802.3 for CSMA/CD (Ethernet), 802.4 for Token Bus (for the factory automation vendors), and 802.5 for Token Ring (drive by IBM) [19].
March 1981	3COM ships its first 10 Mbit/s Ethernet 3C100 transceiver [22].
September 1981	With the fourth version the Transmission Control Protocol (TCP) and the Internet Protocol are published in separate documents, RFC 793 [23] and RFC 791 [24].
August 1982	Simple Mail Transfer Protocol (SMTP) is published as RFC 821 [25].
September 1982	3COM ships the first Ethernet adapter for IBM PCs [8].

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November 1982	The second version of the DIX Ethernet Standard is published [26].
1983	IEEE publishes 802.3 10BASE-5 for 10 Mbit/s over thick coaxial cable [27].
1983	The trade press names at least 21 companies either developing or manufacturing Ethernet products: the five startups (3COM, U-B, Interlan, Bridge Communications, and Excelan), eight computer manufacturers (DEC, Hewlett-Packard, Data General, Siemens, Tektronix, Xerox, ICL, and NCR), and seven chip manufacturers (Intel, AMD, Mostek, Seeq, Fujitsu, Rockwell, and National Semiconductors), all fiercely competing [19].
1983	BOSCH starts a company internal project to develop CAN [28].
1 January 1984	The AT&T monopoly is broken when existing installed telephone wiring is made useable for services by competing companies [1].
By 1985	Approximately 30 000 Ethernet networks installed, connecting at least 419 000 nodes [19].
1985	IEEE publishes 802.3 10BASE-2 for 10 Mbit/s over thin coaxial cable [27].
1986	Market introduction of Token Ring, which quickly gains momentum as it is able to use telephone wires, is more reliable, and easier to troubleshoot than Ethernet [19].
Mid 1987	SynOptics (a Xerox spin-off) ships the first (proprietary) 10 Mbps Ethernet version for telephone wire. Even though this solution is proprietary, it proves the feasibility [19].
December 1987	BMW introduces the first car with a communication bus for diagnostic purposes.
1987	200 vendors of Ethernet equipment counted [19].
1988	The all-electronic fly-by-wire system is introduced into commercial airplane service (on the Airbus A320) [29].
October 1989	Publication of the TCP/IP Internet protocol suite as "Requirements for Internet Hosts – Communication Layers," RFC 1122 [30] and "Requirements for Internet Hosts – Application and Support," RFC 1123 [31].
1989/90	The World Wide Web is invented at CERN [32].
September 1990	IEEE 802.3 ratifies 10BASE-T [27] (with some effort, as various proprietary solutions had evolved [19]). Ethernet won the battle against competing technologies by adapting to market realities and shifting from coaxial to twisted pair [8].
1991	TIA publishes TIA-568. It describes an inexpensive and easy to maintain UTP structured wiring plant. This includes the definition of pin/pair assignments for eight-conductor 100-ohm balanced twisted-pair cabling for wires in 8P8C/RJ-45 eight-pin modular connector plugs and sockets [33].

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1992	The first cars using CAN roll off the assembly line at Mercedes Benz [28].
1993	IEEE 802.3 releases 10BASE-F, the first of a large number of optical versions [27].
June 1994	Initial release of the first automotive quality specification for integrated circuits, AEC Q100 [34].
June 1995	IETF releases the IPv4 specification "Requirements for IP Version 4 Routers," RFC 1812 [35].
August 1995	IETF releases the first IPsec specification, RFC 1825 [36].
December 1995	IETF releases the first specification for IPv6 as RFC 1883 [37].
1995	The first commercial VoIP product allows real-time, full duplex voice communication over the Internet with 1995 available hardware and bandwidth [38].
1995	IEEE 802.3 releases 100BASE-TX (-T4, -FX) including autonegotiation [27].
1995	The ISO/IEC publishes a backwards compatible MPEG-2 Audio (MPEG-2 Part 3) specification – commonly referred to as MP3 – with additional bit and sample rates [39].
14 February 1996	The Windows 95 Service Pack-1 includes Explorer 2.0 (i.e. built-in TCP/IP networking) [11, 40, 41].
May 1996	HTTP/1.0 is published as RFC 1945 [42].
April 1997	The Fieldbus Foundation funds the project to develop the "High-Speed Ethernet (HSE)" Industrial Ethernet version [43].
1997	IEEE 802.3 releases 802.3x full duplex and flow control [27].
December 1998	IETF publishes the "Internet Protocol, Version 6 (IPv6) Specification," RFC 2460 [44].
1998	IEEE 802.3 releases 802.3ac, which extends the maximum frame size to 1522 bytes, in order to allow 802.1Q VLAN information and 802.1p priority information to be included ("Q-tag") [27].
1998	Founding of the LIN consortium by Audi, BMW, Daimler, Volkswagen, Volvo, Freescale (formerly Motorola), and Mentor Graphics (formerly Volcano) [45].
10 September 1998	Founding of the MOST corporation by BMW, Daimler, OASIS (now Microchip), and (Harman) Becker [46].
May 1999	Napster is launched and significantly simplifies MP3 music sharing. It closed in February 2001 [47].
1999	IEEE 802.3 releases the 1000BASE-T specification 802.3ab [27].
May 2000	Boeing delivers its first 747-400, which includes an advanced flight deck display system that uses the Rockwell Collins-developed, Ethernet-based Avionics Systems Network (ASN) as a communication system [48].
31 December 2000	IEC adopts its IEC 61158 standard on fieldbusses. It contains no less than 18 variants, including the three Ethernet-based variants HSE, EtherNet/IP, and Profinet [49].

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2000	Freescale (formerly Motorola), NXP (formerly Philips), BMW, and Daimler found the FlexRay Consortium [50].
October 2001	Daimler is the first car manufacturer to introduce LIN [51].
November 2001	The first car with MOST bus and an LVDS pixel link goes into production at BMW.
November 2002	Release of the IEEE 1588 PTP standard, which had been initiated a few years earlier by Agilent Technologies [52].
10 June 2003	Release of the ARINC Specification 664 Part 2, "Ethernet Physical and Data-Link Layer Specification" [53].
November 2003	LIN 1.3 is published [45].
2003	IEEE 802.3 releases the first Power-over-Ethernet (PoE) specification (IEEE 802.3af) [27].
2003	The AUTOSAR consortium is founded by BMW, BOSCH, Continental, DaimlerChrysler (today Daimler), Siemens VDO (today Continental), and Volkswagen [54].
February 2004	The Metro Ethernet Forum releases the first of a number of standards for the deployment of Carrier Ethernet [55].
July 2004	IEEE 802.3 passes a CFI on "Residential Ethernet" and starts a respective SG, i.e. the Audio Video Bridging (AVB) activities [56].
September 2004	IEEE 802.3 releases the first Ethernet in the First Mile (EFM) specification (IEEE 802.3ah) [27].
2004	Start of investigations at BMW to use Ethernet as an in-car networking technology.
27 April 2005	First flight of the A380 using an AFDX network for its avionics system, see e.g. [57].
27 June 2005	Publication of the ARINC 664 Part 7 specification on "Avionics Full Duplex Switched Ethernet (AFDX) network" [53].
21 November 2005	The AVB activities are shifted from IEEE 802.3 to IEEE 802.1 [58].
February 2006	First cars with built-in USB interface for connecting consumer devices are sold [59, 60].
November 2006	BMW produces the first car with a FlexRay bus [61].
2006	IEEE 802.3 releases the 10GBASE-T specification (IEEE 802.3an) [27].
2007	Toyota introduces the first car with MOST 50 [62].
January 2008	First measurements of BroadR-Reach Ethernet at BMW.
October 2008	SOP (Start of Production) of the BMW 7-series using 100BASE-TX unshielded as a diagnostic interface and 100BASE-TX shielded for the communication between HU and RSE [63].
March 2009	GENIVI Alliance founded by BMW, Delphi, General Motors, Intel, Magneti Marelli, PSA Peugeot Citroën, Visteon, and Wind River [64].

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25 August 2009	AVnu Alliance founded by Broadcom, Cisco, Harman, Intel, and Xilinx [65].
January 2010	First informal discussion among various car manufacturers and FTZ on UTSP Ethernet [66].
March 2010	BMW internal decision on using BroadR-Reach Ethernet for the next surround view system [66].
2010	IEEE 802.3 releases 802.3az on Energy Efficient Ethernet [27].
January 2011	First discussion between Broadcom, NXP, and BMW on founding the OPEN Alliance [66].
31 January 2011	The IANA assigns the last two available blocks of IPv4 addresses [67].
March 2011	BMW internal decision on using BroadR-Reach for the infotainment domain [66].
9 November 2011	NXP, Broadcom, and BMW start the OPEN Alliance. In the same month C&S, Freescale, Harman, Hyundai, Jaguar Landrover, and UNH-IOL join [68].
9 November 2011	NXP announces the development of a BroadR-Reach compliant PHY [69].
14 November 2011	First Ethernet&IP@Automotive Technology Day at BMW in Munich [70].
30 September 2011	The IEEE ratifies and publishes the last of its "Audio Video Bridging (AVB)" standards (IEEE 802.1BA) [71].
February 2012	The Metro Ethernet Forum publishes a suite of specifications as Carrier Ethernet 2.0 [72].
March 2012	Call for Interest (CFI) for Reduced Twisted Pair Gigabit Ethernet (RTPGE) at IEEE 802.3 [73].
19 September 2012	Second Ethernet&IP@Automotive Technology Day hosted by Continental in Regensburg [74].
September 2012	Audi starts production of its first car with a MOST 150 network [75].
November 2012	IEEE renames the AVB activities as Time Sensitive Networking (TSN) [76].
January 2013	Start of RTPGE task force at IEEE 802.3 [77].
25 September 2013	Third Ethernet&IP@Automotive Technology Day hosted by BOSCH in Stuttgart [78].
September 2013	SOP of the BMW X5 with UTSP/OABR Ethernet [66].
January 2014	The OPEN Alliance has 200 members.
September 2015	Expected SOP for BMW with Ethernet system bus [66].

References

[1] AT&T, "Milestones in AT&T History," 2013. [Online]. Available: http://www.corp.att.com/history/milestones.html [Accessed 23 June 2013].

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CAMBRIDGE

Cambridge University Press
978-1-107-05728-9 - Automotive Ethernet
Kirsten Matheus and Thomas Königseder
Frontmatter
More information

[2] A. Dunn, "The Father of Invention: Dick Morley Looks Back on the 40th Anniversary of the PLC," 12 September 2008. [Online]. Available: http://www.automationmag.com/features/the-father-of-invention-dick-morley-looks-back-on-the-40th-anniversary-of-the-plc.html [Accessed 27 July 2013].
[3] M. Lasar, "The UNIX Revolution – Thank You, Uncle Sam?," arstechnica, 19 July 2011. [Online]. Available: http://arstechnica.com/tech-policy/2011/07/should-we-thank-for-feds-for-the-success-of-unix/ [Accessed 23 May 2013].
[4] S. Crocker, "Host Software," 7 April 1969. [Online]. Available: http://tools.ietf.org/html/rfc1 [Accessed 4 August 2013].
[5] Wikipedia, "ARPANET," 29 July 2013. [Online]. Available: http://en.wikipedia.org/wiki/ARPANET [Accessed 4 August 2013].
[6] Wikipedia, "History of the Internet," 31 October 2013. [Online]. Available: http://en.wikipedia.org/wiki/History_of_the_Internet [Accessed 15 November 2013].
[7] Wikipedia, "Unix," 17 May 2013. [Online]. Available: http://en.wikipedia/wiki/Unix [Accessed 19 May 2013].
[8] R. Metcalfe, Interviewee, *The History of Ethernet*. [Interview]. 14 December 2006.
[9] C. E. Spurgeon, *Ethernet: The Definitive Guide*, Sebastopol, CA: O'Reilly, 2000.
[10] D. E. Möhr, "Was bittet bedeutet EMV?," 2013. [Online]. Available: http://www.emtest.de/de/what_is/emv-emc-basics.php [Accessed 17 December 2013].
[11] Wikipedia, "Internet Protocol Suite," 30 June 2013. [Online]. Available: http://en.wikipedia.org/wiki/Internet_protocol_suite [Accessed 5 July 2013].
[12] R. M. Metcalfe, D. R. Boggs, C. P. Thacker, and B. W. Lampson, "Multipoint Data Communication System (With Collision Detection)." U.S. Patent 4 063 220, 31 March 1975.
[13] S. Djiev, "Industrial Networks for Communication and Control," 2013. [Online]. Available: http://anp.tu-sofia.bg/djiev/PDF%20files/Industrial%20Networks.pdf [Accessed 25 July 2013].
[14] D. Boggs and R. Metcalfe, "Ethernet: Distributed Packet Switching for Local Computer Networks," *Communications of the ACM*, vol. 19, no. 7, pp. 395–405, July 1976.
[15] A. L. Russell, "OSI: The Internet That Wasn't," 29 July 2013. [Online]. Available: http://spectrum.ieee.org/computing/networks/osi-the-internet-that-wasnt [Accessed 21 August 2013].
[16] W. Stallings, "The Origin of OSI," 1998. [Online]. Available: http://williamstallings.com/Extras/OSI.html [Accessed 12 May 2013].
[17] Wikipedia, "Berkeley Software Distribution," 12 May 2013. [Online]. Available: http://en.wikipedia.org/wiki/Berkeley_Software_Distribution [Accessed 5 July 2013].
[18] Avionics Interface Technologies, "ARINC 429 Protocol Tutorial," Avionics Interface Technologies. [Online]. Available: http://aviftech.com/files/2213/6387/8354/ARINC429_Tutorial.pdf [Accessed 14 July 2013].
[19] U. v. Burg and M. Kenny, "Sponsors, Communities, and Standards: Ethernet vs. Token Ring in the Local Area Networking Business," *Industry and Innovation*, vol. 10, no. 4, pp. 351–375, December 2003.
[20] J. Postel, "User Datagram Protocol," 29 August 1980. [Online]. Available: http://tools.ietf.org/html/rfc768 [Accessed 4 August 2013].
[21] Digital Equipment Corporation, Intel Corporation, Xerox Corporation, "The Ethernet, A Local Area Network. Data Link Layer and Physical Layer Specifications, Version 1.0," 30 September 1980. [Online]. Available: http://ethernethistory.typepad.com/papers/EthernetSpec.pdf [Accessed 23 June 2013].

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CAMBRIDGE

Cambridge University Press
978-1-107-05728-9 - Automotive Ethernet
Kirsten Matheus and Thomas Königseder
Frontmatter
More information

[22] Wikipedia, "Ethernet," 22 June 2013. [Online]. Available: en.wikipedia.org/wiki/Ethernet [Accessed 23 June 2013].
[23] Information Sciences Institute University of Southern California, "Transmission Control Protocol," September 1981. [Online]. Available: http://tools.ietf.org/html/rfc793 [Accessed 4 August 2013].
[24] Information Sciences Institute University of Southern California, "Internet Protocol," September 1981. [Online]. Available: http://tools.ietf.org/html/rfc791 [Accessed 4 August 2013].
[25] J. Postel, "Simple Mail Transport Protocol," August 1982. [Online]. Available: http://tools.ietf.org/html/rfc821 [Accessed 4 August 2013].
[26] Digital Equipment Corporation, Intel Corporation, Xerox Corporation, "The Ethernet, A Local Area Network. Data Link Layer and Physical Layer Specifications, Version 2.0," November 1982. [Online]. Available: http://decnet.ipv7.net/docs/dundas/aa-k759b-tk.pdf [Accessed 23 June 2013].
[27] Wikipedia, "IEEE 802.3," 24 February 2013. [Online]. Available: http://en.wikipedia.org/wiki/IEEE_802.3 [Accessed 19 May 2013].
[28] CiA, "CAN History," 2013. [Online]. Available: http://www.can-cia.de/index.php?id=161 [Accessed 23 August 2013].
[29] Condor Engineering, "AFDX Protocol Tutorial," May 2005. [Online]. Available: http://www.cems.uwe.ac.uk/~ngunton/afdx_detailed.pdf [Accessed 15 July 2013].
[30] R. Braden, "RFC 1122," October 1989. [Online]. Available: http://tools.ietf.org/pdf/rfc1122.pdf [Accessed 23 June 2013].
[31] R. Braden, "RFC 1123," October 1989. [Online]. Available: http://tools.ietf.org/pdf/rfc1123.pdf [Accessed 26 June 2013].
[32] P. Barford, "The World Wide Web," University of Wisconsin, 11 September 2008. [Online]. Available: http://pages.cs.wisc.edu/~pb/640/web.ppt [Accessed 6 August 2013].
[33] Wikipedia, "TIA/EIA-568," 5 June 2013. [Online]. Available: https://en.wikipedia.org/wiki/TIA/EIA-568 [Accessed 23 June 2013].
[34] Automotive Electronics Council, "AEC History," 2013. [Online]. Available: http://www.aecouncil.com/AECHistory.htm [Accessed 17 December 2013].
[35] F. Baker, "Requirements for IP Version 4 Routers," June 1995. [Online]. Available: http://tools.ietf.org/pdf/rfc1812.pdf [Accessed 23 June 2013].
[36] R. Atkinson, "Security Architecture for the Internet Protocol," August 1995. [Online]. Available: http://tools.ietf.org/html/rfc1825 [Accessed 2 February 2014].
[37] S. Deering and R. Hinden, "Internet Protocol, Version 6 (IPv6)," December 1995. [Online]. Available: http://tools.ietf.org/html/rfc1883 [Accessed 23 November 2013].
[38] iLocus, "The 10 That Established VoIP," September 2007. [Online]. Available: http://www.ilocus.com/sites/default/files/The%2010%20That%20Established%20VoIP.pdf [Accessed 8 August 2013].
[39] ISO/IEC, "ISO/IEC 13818–3:1995, Information Technology – Generic Coding of Moving Pictures and Associated Audio Information – Part 3: Audio," ISO, Geneva, 1995.
[40] Wikipedia, "Windows 95," 21 June 2013. [Online]. Available: http://en.wikipedia.org/wiki/Windows_95 [Accessed 23 June 2013].
[41] Microsoft, "Beschreibung von Microsoft Windows 95 Service Pack 1-Komponenten," 14 February 2006. [Online] [Accessed 23 June 2013].
[42] T. Berners-Lee, R. Fielding, and H. Frystyk, "HTTP/V1.0," May 1996. [Online]. Available: http://tools.ietf.org/html/rfc1945 [Accessed 4 August 2013].

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CAMBRIDGE

Cambridge University Press
978-1-107-05728-9 - Automotive Ethernet
Kirsten Matheus and Thomas Königseder
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More information

[43] Contemporary Controls, "Dick Caro – One of the Most Influential Persons in the Field of Industrial Networking – Part 2," 2006. [Online]. Available: http://www.ccontrols.com/pdf/Extv6n3.pdf [Accessed 15 August 2013].

[44] S. Deering and R. Hinden, "Internet Protocol, Version 6 (IPv6) Specification," December 1998. [Online]. Available: http://tools.ietf.org/pdf/rfc2460.pdf [Accessed 23 June 2013].

[45] D. Marsh, "LIN Simplifies and Standardizes In-vehicle Networks," *EDN*, pp. 29–40, 28 April 2005.

[46] A. Grzemba, *MOST, The Automotive Multimedia Network: From MOST 25 to MOST 150*, Poing: Franzis Verlag GmbH, 2011.

[47] T. Lamont, "Napster: The Day the Music Was Set Free," *Guardian*, 24 February 2013. [Online]. Available: http://www.theguardian.com/music/2013/feb/24/napster-music-free-file-sharing [Accessed 30 October 2013].

[48] J. W. Ramsey, "Boeing's 767–400ER: Ethernet Technology Takes Wing," 1 May 2000. [Online]. Available: http://www.aviationtoday.com/av/commercial/Boeings-767-400ER-Ethernet-Technology-Takes-Wing_12652.html [Accessed 2 August 2013].

[49] M. Felser and T. Sauter, "Standardization of Industrial Ethernet – The Next Battlefield?," *Proc. IEEE 5th International Workshop on Factory Communication Systems*, pp. 413–421, 22 September 2004.

[50] U. Niggli, "FlexRay, Eine Übersicht über die neue Datenbus-Generation für den Automobil-Bereich," January 2006. [Online]. Available: https://prof.hti.bfh.ch/uploads/media/flexray.pdf [Accessed 24 September 2013].

[51] D. Müller, D. Sommer, and S. Stegemann, "Local Interconnect Network (LIN)," 13 November 2009. [Online]. Available: http://prof.beuth-hochschule.de/uploads/media/LIN-Bus_MuellerSommerStegemann.pdf [Accessed 17 September 2013].

[52] Hirschmann, "Precision Clock Synchronization, The Standard IEEE 1588," 2008. [Online]. Available: http://www.belden.com/docs/upload/precision_clock_synchronization_wp.pdf [Accessed 28 October 2013].

[53] AIM GmbH, "AFDX Workshop," March 2010. [Online]. Available: http://www.afdx.com/pdf/AFDX_Training_October_2010_Full.pdf [Accessed 13 July 2013].

[54] F. Leitner, "AUTOSAR AUTomotive Open System ARchitecture," 2007. [Online]. Available: http://www.inf.uni-konstanz.de/soft/teaching/ws07/autose/leitner-autosar.pdf [Accessed 9 October 2013].

[55] Metro Ethernet Forum, "MEF Technical Specifications," Metro Ethernet Forum, January 2011. [Online]. Available: http://metroethernetforum.org/carrier-ethernet/technical-specifications [Accessed 11 August 2013].

[56] IEEE 802.3, "Residential Ethernet, IEEE 803.2 Call for Interest," July 2004. [Online]. Available: http://grouper.ieee.org/groups/802/3/re_study/public/200407/cfi_0704_1.pdf [Accessed 12 October 2013].

[57] Guardian, 27 April 2005. [Online]. Available: http://www.guardian.co.uk/gall/0,,1393041,00.html [Accessed 17 July 2013].

[58] IEEE 802.3, "IEEE 802.3 Residential Ethernet Study Group," 21 November 2005. [Online]. Available: http://grouper.ieee.org/groups/802/3/re_study/ [Accessed 11 October 2013].

[59] just-auto, "USA: Cars to Get USB Ports Soon – CD Players to Become Obsolete?," 31 October 2005. [Online]. Available: http://www.just-auto.com/news/cars-to-get-usb-ports-soon-cd-players-to-become-obsolete_id84660.aspx [Accessed 15 September 2013].

[60] bookofjoe, "Microsoft Windows Automotive – World's First Production Car With a Factory-installed USB Port," 12 March 2006. [Online]. Available: http://www.bookofjoe.com/2006/03/microsoft_windo.html [Accessed 15 September 2013].

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CAMBRIDGE

Cambridge University Press
978-1-107-05728-9 - Automotive Ethernet
Kirsten Matheus and Thomas Königseder
Frontmatter
More information

[61] F. Völkel, "BMW X5: ERstes Auto mit FlexRay Datenbus," 17 August 2006. [Online]. Available: http://www.tomshardware.de/bmw-x5-flexray-datenbus,testberichte-1546.html [Accessed 15 September 2013].

[62] H. Schoepp, "In-vehicle Networking Today and Tomorrow," 17 January 2012. [Online]. Available: http://www.automotive-eetimes.com/en/in-vehicle-networking-today-and-tomorrow.html?cmp_id=71&news_id=222902008 [Accessed 28 August 2013].

[63] K. Matheus, "OPEN Alliance – Stepping Stone to Standardized Automotive Ethernet," in *2nd Ethernet&IP@Automotive Technology Day*, Regensburg, 2012.

[64] B. Wuelfing, "CeBIT 2009: BMW and Partners Found GENIVI Open Source Platform," 3 March 2009. [Online]. Available: http://www.linuxpromagazine.com/Online/News/CeBIT-2009-BMW-and-Partners-Found-GENIVI-Open-Source-Platform [Accessed 10 October 2013].

[65] Business Wire, "AVnu Alliance Launches to Advance Quality of Experience for Networked Audio and Video," 25 August 2009. [Online]. Available: http://www.businesswire.com/news/google/20090825005929/en [Accessed 8 October 2013].

[66] K. Matheus, "Structural Support for Developing Automotive Ethernet," in *3rd Ethernet&IP@Automotive Technology Day*, Stuttgart, 2013.

[67] Number Resource Organization, "Free Pool of IPv4 Address Space Depleted," 3 February 2011. [Online]. Available: http://www.nro.net/news/ipv4-free-pool-depleted [Accessed 23 November 2013].

[68] PR Newswire, "Broadcom, NXP, Freescale, and Harman Form OPEN Alliance Special Interest Group," 9 November 2011. [Online]. Available: http://www.prnewswire.com/news-releases/broadcom-nxp-freescale-and-harman-form-open-alliance-special-interest-group-133514928.html [Accessed 9 November 2011].

[69] marketwire, "NXP Develops Automotive Ethernet Transceivers for In-Vehicle Networks," 9 November 2011. [Online]. Available: http://www.msnbc.msn.com/id/45219956 [Accessed 9 November 2011].

[70] I. Riches, "BMW 1st Ethernet & IP @ Automotive Techday – Momentum Achieved," 14 November 2011. [Online]. Available: http://blogs.strategyanalytics.com/AES/post/2011/11/16/BMW-1st-Ethernet-IP-Automotive-Techday-Momentum-Achieved.aspx [Accessed 18 November 2011].

[71] Wikipedia, "Audio Video Bridging," 25 June 2013. [Online]. Available: http://en.wikipedia.org/wiki/Audio_Video_Bridging [Accessed 5 July 2013].

[72] P. Marwan, "Carrier Ethernet 2.0 ist an den Start gegangen," 28 February 2012. [Online]. Available: http://www.zdnet.de/41560473/carrier-ethernet-2-0-ist-an-den-start-gegangen/ [Accessed 11 August 2013].

[73] IEEE 802.3, "Reduced Twisted Pair Gigabit Ethernet Call For Interest," March 2012. [Online]. Available: http://www.ieee802.org/3/RTPGE/public/mar12/CFI_01_0312.pdf [Accessed 15 March 2012].

[74] C. Wirth, "Die Netzwerktechnologie Ethernet verspricht eine neue Zukunft im Auto," 10 January 2013. [Online]. Available: https://www.hs-regensburg.de/hochschule/aktuelles/einzelansicht/article/it-anwenderzentrum-ist-beim-thema-ethernet-im-auto-ganz-vorn-mit-dabei.html [Accessed 11 October 2013].

[75] MOST Corporation, "MOST150 Inauguration in Audi A3," *MOST Informative*, no. 8, p. 2, October 2012.

[76] IEEE 802.1, "802.1 Plenary – 11/2012 San Antonio Closing," November 2012. [Online]. Available: http://www.ieee802.org/1/files/public/minutes/2012-11-closing-plenary-slides.pdf [Accessed 30 October 2013].

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[77] IEEE 802.3, "Unconfirmed Minutes IEEE 802.3 Ethernet Working Group PLENARY Grand Hyatt, San Antonio, TX USA," 14–18 November 2012. [Online]. Available: http://www.ieee802.org/3/minutes/nov12/minutes_1112.pdf [Accessed 7 October 2013].

[78] Hanser Automotive, "Rückblick: 3rd Ethernet & IP @ Automotive Technology Day," *Hanser Automotive Sonderheft Automotive Networks*, November 2011.

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