

Inventing the Cloud Century

Marcus Oppitz • Peter Tomsu

Inventing the Cloud Century

How Cloudiness Keeps Changing Our Life,
Economy and Technology

Marcus Oppitz
Klosterneuburg
Austria

Peter Tomsu
Leitzersdorf
Austria

ISBN 978-3-319-61160-0 ISBN 978-3-319-61161-7 (eBook)
DOI 10.1007/978-3-319-61161-7

Library of Congress Control Number: 2017944452

© Springer International Publishing AG 2018

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

*To our wives, Irmgard and Tanja for their
patience
And to our families*

Preface

The idea for this book was formed in the spring of 2015. We were working for Cisco at that time, one of the large players in network technology. Like every other company in the market, Cisco was on its way to embrace the new opportunities generated by cloud computing and the Internet of Things. Fascinated with bringing together the concept of cloud services and new network architectures to create new business models, we started to work on a model involving different types of ownerships to create a more precise definition of what cloud-based services could offer. The result was a first initial publication; a short summary is part of the chapter entitled “Cloud Computing.” Soon we discovered that we had touched the tip of an iceberg. Cloud computing and cloud services seemed to be nothing more than the momentary status of an evolution that was started long ago and that was on its way to change economy, technology, and society in an accelerating and dramatic way.

Both of us had started our careers as engineers in the mid-1970s at the University of Technology Vienna at the time when computing and computer sciences began its journey toward a key technology for businesses. Our working environment was dictated by mainframe computers, by punch cards, and—if you were lucky—by very simple green-screen terminals. After university, we went on different paths in our professional careers. Marcus started to work in the software business building own companies and start-ups. Peter concentrated a great part of his professional life on the development and deployment of new networking technologies and cloud architectures. When we met again, 40 years later, everything had changed completely. Computers went into the background; they became a kind of commodity in your shirt pocket. Networks, the Internet, the Web, and Web-based services had become the driving power for computer science, business, and society. Smart environments using cognitive computing and the Internet of Things had started to disrupt many businesses and industry segments. Digitalization had become a prerequisite for all kinds of organizations or corporations, requiring the acceptance of new technologies but also creating a demand for change and transition of business models. The social and political impact of social media pulled communities into the global village and created many new challenges for politics and media.

Within those 40 years, we had been part of a huge transition starting with the first PCs and networks in the 1970s and moving to the expansion of the Internet, to the revolution triggered by the Web, and to the concept of cloud computing and cloud business today.

Those changes and transitions gained speed over the last decades and seem to point to a future that would be influenced by the economy of cloud-based services. Exploring the path of this evolution and trying projections into the future became a fascinating idea for both of us. There are Terabytes of literature about technological developments, social and political impacts, and the rapidly changing economy. What we had in mind is the interlock of these three dimensions to explore the making of today's cloud ecosystems as witnessed by followers of older service ecosystems that were based on networks. We also wanted to describe the move of services to the cloud and the long-term trend that is still progressing at high velocity. Successful technology is always accompanied by compelling business models and ecosystems including private, public, and federal organizations. Our target was to explore the evolution of service ecosystems, describe their similarities and differences, and analyze the way they created and changed industries. Based on the status of cloud computing and related technologies like virtualization, Internet of Things, fog computing, big data, and analytics, we tried to provide an outlook into the possibilities of future technologies, the future of the Internet, and the possible impacts on business and society moving to the cloud century.

This book is our result.

We address readers like engineers, historians, or economists who are interested in an interdisciplinary view on the history, status, and future projection of the Internet, the Web, and cloud computing. We aimed to connect the technical view with the economic history and the social effects of service ecosystems based on networks. We have tried to follow a storytelling approach, moving along the lines of historical evolution. While sometimes drilling down into technical details, this is not a technical textbook.

Vienna
2017

Marcus Oppitz
Peter Tomsu

Contents

- Introducing Cloudiness** 1
 - In Search for a Better Life 2
 - Service Ecosystems: The Five Magic Elements 6
 - Creation and Innovation 10
 - Structure of the Book 14
- References 19
- A Short History of Service Ecosystems** 21
 - Cloud: An Old Concept 22
 - Water 23
 - Public Transport and Postal Services 25
 - The First Transport Networks 25
 - International Rollout 30
 - Business and Market Today 31
 - Social Impact 32
 - Railway 33
 - Technology 1.0: The Steam Age 35
 - Technology 2.0: Electricity, Diesel and High-Speed 40
 - Social and Economic Impact 42
- References 44
- Early Information Network Services** 45
 - The First Optical Communication Network 45
 - Social and Economic Impact 47
 - The Electric Telegraph 48
 - Social and Economic Impact 56
 - Telephone 58
 - Technology 58
 - Building an Ecosystem 60
 - Social and Economic Impact 63
 - Wireless 64

Technology	64
Building Business: The Begin of the Electronic Industry	66
Standards	67
Broadcasting	68
Technology	68
Building Radio Business	69
Standards and Regulation	70
Social Impact	71
Status Before Internet and Cloud Computing	71
References	72
Making of Digital Computers	75
History of Computing	77
From Mechanical to Electrical Computing	77
1928–1936: Mathematical Theory—Gödel, Turing and von Neumann	78
1936 The Turing Machine	78
Von Neumann Architecture	80
Women and the Development of Computers	81
The Birth of IBM: The Mother of Mainframes	82
1960 Mainframes and Early Computing	82
Early User Interfaces	83
Mainframe and Virtualization	83
The Big Mainframe Players	84
1970 The Rise of Minicomputers	85
1980 Personal Computers	85
The Homebrew Computer Club	86
Computers from the Starting Period	87
1977 Apple II: The First Personal Computer for Everyone	87
The Rise of PCs	88
1980 From Personal Computers to Workstations	89
1990 PCs Getting Mature	90
1990s Servers Replacing Mainframes	92
2010 Mainframes Renaissance	92
Supercomputers Versus Modern Mainframes	93
Mainframes in the Middle of the 2010s	94
The Economic Cloud Solution	94
References	95
Networks for Sharing and Connecting	97
Evolution of Computer Networks	97
Ethernet: The Epic Foundation for Local Area Networks	100
Other Local Area Network Standards	102
From Ethernet to Structured Cabling	104
Principles of Layered Networking	104
Bridges Expanding LANs Beyond Cabling Limitations	105

Switches Enabling Scalable Fast Networking	107
Routers and Cisco	108
Networking Standards	109
The Birth of Modern Networking	110
The Internet Protocol Suite	112
Internet Protocol Suite Layers Defined	114
OSI Reference Model	115
ATM: Attempt to Integrate Data and Voice	117
The Success of the Internet Protocol Suite	121
Internet Protocol Next Generation aka IPv6	123
IPng/IPv6 Advancements	125
IPv6 Packet Format	127
IPv6 Deployment	128
References	128
Managing Virtual Storage	131
Shared Storage Model	133
Different Types of Storage Virtualization	135
Disk Virtualization	136
Tape Storage Virtualization	136
File System Virtualization	137
File/Record Virtualization	137
Block Virtualization	138
References	138
From Physical to Virtual Servers	139
Server Virtualization Overview	139
Server Virtualization Methods in Detail	141
Open Virtualization Format (OVF)	146
References	148
Software Defined Virtual Networks	149
Some SDN History and Evolution	149
Legacy Networking Limitations Driving SDN	151
SDN Disrupting Legacy Networking	155
Concept and Promise of SDN	158
High Level View of SDN	159
Centralized Versus Distributed Control and Data Planes	162
Control Plane	163
Forwarding and Data Plane	165
Separation of Control and Data Planes	165
Different Functional Planes of Network Elements	167
Evolution of Control Plane Concepts	168
Open SDN Implementations	171
OpenFlow	171
OpenDaylight (ODL)	179
Open Compute Project (OCP)	181

SDN Market and Implementations	182
VMware and Nicira	183
Cisco ACI: Application Centric Infrastructure	187
Big Switch Networks	194
References	199
Building the Internet	201
Preparations	202
Connecting Machines and People	203
Building the Basement: Unix and C	210
Open Systems	214
Rollout of the Internet	219
Connecting to the Internet	219
The First Communities	220
The Commercialization of the Internet	221
The IT Market at the End of the 1980s	226
The Internet Before the Web	226
Reference	227
World Wide Web	229
The World Wide Web Is Born	229
Browsers	233
Sharing Pictures, Music and Video	235
Starting with Web Portals and Search	237
Improving Efficiency: Java, PHP and Web Services	240
Building First Businesses	244
Starting with e-Commerce	244
Smart Search: Google and Followers	247
Free Content	250
The Dot-com Bubble	251
The IT Market in the Early 2000s	253
Web 2.0 and the Social Networks	253
Travel	255
Social Media: Facebook and Others	257
Pictures, Music and Video	259
Mobile and Smart	261
The IT Market in 2005	261
Leaving the Desk	262
A Disruptive Business Model for Software	265
The IT Market in 2010	266
Reference	266
Cloud Computing	267
What Is Cloud Computing?	267
Similarities and Differences to Other Service Ecosystems	271
Definitions of Cloud Computing	274

The Official NIST Definition	274
The ITU Cloud Reference Architecture	282
The Ownership Model	283
Native Cloud Applications	286
Moving Towards the Clouds	287
Infrastructure as a Service	289
Software as a Service	295
Office as a Service	298
Chat, Collaboration and Video	302
New Business Models for Media	304
New Business Models for Sharing Resources	306
Social Networking 2	310
Sharing Knowledge and Information	312
References	318
Building Cloud Businesses and Ecosystems	319
Business Models	320
Basic Assumptions	320
Drivers of Acceptance	322
Obstacles	322
Enablers	323
Primary Cloud Infrastructure and Cloud Service Business	325
Cloud Infrastructure	325
Cloud Services	325
Secondary Markets	327
E-Commerce	327
Advertising	328
Travel and Online Booking	328
Media and Entertainment	330
Cloud Market Players	332
IT Companies	332
Internet Companies	336
Semiconductor and Electronics Manufacturers	338
Infrastructure	338
Standards and Standard Organizations	345
Open Source Software	345
Creating Innovation	349
Creative Destruction and Disruption	349
Technology, Paradigms and Ecosystems	351
The Importance of Paradigm Changes	351
Acceleration of Paradigm Changes	352
14 Major Paradigm Changes Since 1950	353
Innovation as Business	358
The Innovation Ecosystem	367

Founders	367
Investors	368
Regions and Hotspots	370
Silicon Valley as Unique Model for Innovation	372
Innovation's Effects	373
New Jobs	374
Quick Success or Fail	374
Innovation Accelerates Productivity	374
Delayed Effect on Economy	375
Reference	375
Security and Privacy Challenges	377
Good, Bad and Ugly	377
A Short History of Private Communication: Secret Messages	379
Machines for Encryption and Decryption	382
Going Industrial: Standard Technology	384
Building Secure Connections for the Internet	388
Creating Standards and Best Practices	395
Security Today	396
Cloud Security Threats and Typical Patterns	399
Security Market	402
Threat Agents and Their Motivations	403
Hackers	403
Whistleblowers	404
Cyberwarfare	404
Industrial Espionage	405
Cybercrime	405
Data Theft	405
Ransomware	406
Fake Emails	407
Phishing Mails	407
CEO Fraud	408
Dark Web and Deep Web	408
The Growth of Cybercrime	409
Defense and Security Policies on Different Levels	409
Reference	410
Changes in Society and Politics	411
The Purpose of the Web and the Clouds	412
The Web as an Amplifier	413
Digitalization	414
Speed of Change	414
Quality of Life	416
Digital Social Networks	417
Privacy, Identity and Security	421

- Trust and Borders 423
 - Building New Trust 423
 - Creating New Borders 426
- The Fight for Rules and Regulations 429
 - Non-Profit Organizations 430
 - Political Initiatives 431
- Reference 433
- Internet of Things 435**
 - IoT in a Nutshell 435
 - Enablers of IoT 439
 - IoT Protocols and Standards 443
 - Cellular IoT Standards 443
 - Industrial IoT (IIoT) and Standards 446
 - Other IoT Standards and Communication Technologies 448
 - Cost of IoT Connectivity 451
 - How the IoT, Cloud and Big Data Play Together 451
 - IoT Reference Model 453
 - IoT Levels 455
 - IoT Security 459
 - IoT Reference Model Status 460
 - IoT Solution Samples 461
 - Parking Space Management 461
 - Precision Agriculture 462
 - Building and Home Automation Systems 464
 - Manufacturing and Industry 4.0 465
 - IoT in Retail Market 467
 - Media, Data Capture, IoT and Big Data 467
 - References 468
- Fog Computing 471**
 - Fog Computing in a Nutshell 471
 - Fog Computing Origin and Definition 471
 - Fog Computing Versus IoT Versus Cloud Computing 472
 - Fog Computing Versus Edge Computing 473
 - Fog Computing Infrastructure 474
 - IoT Mandates Transition from Cloud to Fog 474
 - New Applications Requiring Fog Computing 474
 - Fog Computing as Enabler for IoT Success 476
 - Fog and Cloud Relationship 476
 - Fog Computing System Level Approach 478
 - New Paradigms for Fog: Systems and Macro Endpoints 478
 - Fog Platform Requirements 478
 - Fog Computing Architecture 481
 - Distributed Fog Infrastructure 481

Fog Architecture Network Infrastructure View	482
Emerging Technologies Enabling Fog Computing	482
Fog Computing Solution Samples	483
Smart Traffic Lights (STLs) and Smart Connected Vehicles (SCVs)	484
Wireless Sensor, Actuator Networks (WSANs) and Smart Buildings	485
Smart Grid	486
References	486
Big Data Analytics	487
Big Data Analytics Defined	488
The 5 V's of Big Data	491
Common Big Data Analytics Misconceptions	494
Big Data Analytics Requirements	496
Drivers of Big Data	496
Big Data Analytics Technology Landscape	497
Big Data in Motion	497
Big Data at Rest	497
NoSQL Versus SQL Databases	498
Big Data Analytics Framework	499
Data Source: Capture, Integration and Movement	499
Hadoop, Relational (SQL) and Non-Relational (NoSQL) Databases	500
Hadoop in Detail	501
Non-Structured Data	501
Data Stores: Big Data Management and Processing	502
Applications Functions and Services	502
Business View, Presentation and Consumption	502
The Big Data Analytics Use Cases	503
Big Data Analytics Market	507
References	510
Future Technologies of the Cloud Century	511
The Ever-Increasing Computing Power	511
Parallel CPUs	513
New Materials in Computing	514
The Networking Revolution	514
Constantly Expanding Infrastructure	515
Traffic Increase	516
Changing Applications Means Changing Traffic Patterns	517
Challenges for Legacy IP Networks	517
SDN and Cloud Based Networking Services	518
Big Data Analytics Networking Requirements	519
Wireless Future	520
IPv6	521
The Future Internet	522
Coverage for Several Billion Nodes	522
Speed as Never Seen Before	522

Zettabyte Capacity	523
Balance Between Privacy and Security	525
Next Generation User Interfaces	525
Resilience and Survivability	526
New Dimensions Through IoT and Embedded Systems	527
Swarming and Collaboration	528
Storage Virtualization Future	528
Software Defined Data Center	528
Revolutionized Non-volatile Memory Design	529
Optimized Capacity Large Disk Drives	530
Why Software Defined Storage (SDS) Infrastructure	531
Server Virtualization Evolution	531
From Fiber Channel to Ethernet	532
The Single Data Center Networking Solution	532
Network Virtualization of the Next Decade	533
SDDC and Networking	534
New Demands on Hypervisors	536
SDN Controller Future	536
From Closed to Open SDN Environments	537
IoT and Fog: The Next Big Disruption?	538
From Internet Age to IoT Age	538
Self-Driving and Flying Cars	539
Enormous Economic Benefits Through IoT	540
Next Big Disruption Through IoT	541
Big Data Analytics Changing All Our Lives	542
Triumph of Open Source Tools	542
Big Data Analytics and New Market Segments	543
Predictive Analytics	543
Is Human Decision Making Still Necessary?	544
References	545
New Paradigms and Big Disruptive Things	547
Decentralize: Peer-to-Peer	548
The Bitcoin Story	550
The Technology Behind Bitcoin: How Does Blockchain Work?	552
Cryptocurrencies Replacing Banks	553
Back to Blockchain as a Basic Technology	557
First Applications	559
Distributed Ledger as Disruptive Business Model	561
Cognitive Computing and Machine Intelligence	562
Looking Back to Cybernetics and Artificial Intelligence	564
Cognitive Computing Elements	569
Convergence of Technologies	575
Cognitive Tools in the Market Today	579
Truly Intelligent Clouds	583

Disruptive Future Computing Technologies	586
3-D Molecular Computing and Nanotubes	587
Molecular Computing	587
DNA Computing	588
Controlling Spin	589
Using Light for Computing	589
Quantum Computing	590
References	595
Arrival in the Cloud Century	597
Persons	603

Abbreviations

10Base2	10 Mbps Baseband 200 meter
10Base5	10 Mbps Baseband 500 meter
10BaseT	10 Mbps Baseband Twisted Pair
3G	Third generation of wireless mobile telecommunications technology
3GPP	3rd Generation Partnership Project
4G	Fourth generation of mobile telecommunications standard
5G	Fifth generation of wireless mobile telecommunications technology
AAL	ATM Adaptation Layer
ACE	Automatic Computing Engine
ACI	Application Centric Infrastructure
ADSL	Asymmetric Digital Subscriber Line
ALE	Address Lifetime Expectations
ALU	Arithmetic Logical Unit
AMD	Advanced Micro Devices
ANSI	American National Standards Institute
AOE	ATA over Ethernet
API	Application Program Interface
APIC	Application Centric Infrastructure Controller
ARP	Address Resolution Protocol
ARPA	Advanced Research Projects Agency
ARPA IPTO	Advanced Research Projects Agency Information Processing Techniques Office
ARPANET	Advanced Research Projects Agency Network
AS	Autonomous System
ASCII	American Standard Code for Information Interchange
ASIC	Application Specific Integrated Circuit
ATA	Advanced Technology Attachment

ATM	Asynchronous Transfer Mode
ATM	Automated Teller Machine
AWS	Amazon Web Services
BCF	Big Cloud Fabric
BGP	Border Gateway Protocol
B-ISDN	Broadband Integrated Services Digital Network
BLE	Bluetooth Low Energy
BNC	Bayonett Neill Concelman
BUS	Broadcast and Unknown Server
CAD	Computer Aided Design
CAF	C++ Actor Framework
CBR	Committed Bit Rate
CCITT	Comité Consultatif International Téléphonique et Télégraphique
CD	Compact Disk
CDMI	Cloud Data Management Interface
CDPI	Control to Data Plane Interface
CEP	Complex Event Processing
CHS	Cylinders Heads and Sectors
CIDR	Classless Inter Domain Routing
CISC	Complex Instruction Set Computing
CLI	Command Line Interface
COBOL	Common Business Oriented Language
COM	Component Object Model
CORBA	Common Object Request Broker Architecture
COTS	Commercial Off The Shelf
CPS	Cyber Physical System
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
CRM	Customer Relationship Management
CRT	Cathode Ray Tube
CRUD	Create, Read, Update, Delete
CSMA/CD	Carrier Sense Multiple Access with Collision Detection
CSNET	Computer Science Network
DARPA	Defense Advanced Research Projects Agency
DBMS	Data Base Management System
DC	Data Center
DCOM	Distributed Component Object Model
DDS	Data Distribution Service
DEC	Digital Equipment Corporation
DHCP	Dynamic Host Configuration Protocol
DHCPv6	Dynamic Host Configuration Protocol Version 6
DIX	Digital Intel Xerox
DNS	Domain Name System
DOD	Department of Defense

DoS	Denial of Service
DQDB	Distributed Queue Dual Bus
DRAM	Dynamic Random Access Memory
DSL	Digital Subscriber Loop
DVD	Digital Versatile Disc
EBCDIC	Extended Binary Coded Decimal Interchange Code
EC-GSM-IoT	Extended Coverage GSM for IoT
EGPRS	Enhanced General Packet Radio Service
ELAN	Emulated LAN
ERP	Enterprise Resource Planning
ESCON	Enterprise System Connection
ESG	Enterprise Study Group
ESX	Elastic Sky X
FC	Fiber Channel
FCOE	Fiber Channel Over Ethernet
FDDI	Fiber Distributed Data Interface
FIB	Forwarding Information Base
FICON	Fiber Connection
FLOPS	Floating Point Operations Per Second
FPGA	Field Programmable Gate Array
FTP	File Transfer Protocol
FTTH	Fiber To The Home
GC&CS	Government Code and Cypher School
GE	General Electric
GFC	Generic Flow Control
GFLOPS	Giga Floating Point Operations per Second
GIG	Global Information Grid
GMO	Genetically Modified Organism
GMR	Giant Magneto Resistive
GNSS	Global Navigation Satellite System
GNU	GNU's not Unixe
GPL	General Public License
GPRS	General Packet Radio Service
GPS	Global Positioning System
GRE	Generic Route Encapsulation
GSM	Global System for Mobile Communications
GSMA	Global System Mobile Association
GUI	Graphical User Interface
HA	High Availability
HC	Hop Count
HCC	Homebrew Computer Club
HDFS	Hadoop Distributed File System
HEC	Header Error Correction
HMI	Human Machine Interface

HPC	High Performance Computing
HRMS	Human Resource Management System
HSM	Hierarchical Storage Management
HSPA	High Speed Packet Access
HTTP	Hyper Text Transfer Protocol
IaaS	Infrastructure as a Service
IBM	International Business Machines
IC	Incubation Committee
ICMPv6	Internet Control Message Protocol Version 6
IDC	International Data Corporation
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IGP	Interior Gateway Protocol
IIoT	Industrial Internet of Things
Intel VT	Intel Virtualization Technology
IoE	Internet of Everything
IoT	Internet of Things
IOTC	Internet of Things Consortium
IoTSF	IoT Security Foundation
IoTWF	Internet of Things World Forum
IP	Internet Protocol
IPng	IP Next Generation
IPU	Instruction Processing Unit
IPv4	Internet Protocol Version 4
IPv6	IP Version 6
iscsi	Internet Small Computer System Interface
ISDN	Integrated Services Digital Network
ISIS	Intermediate System to Intermediate System
ISM	Industrial Scientific and Medical
ISO	International Standards Organization
ISP	Internet Service Provider
IT	Information Technology
ITS	Intelligent Transportation System
ITU	International Telecommunication Union
ITU-T	Telecommunication Standardization Sector of the International Telecommunications Union
IXP	Internet Exchange Point
KVM	Kernel Virtual Machine
LAN	Local Area Network
LANE	LAN Emulation
LBA	Logical Block Addressing
LCD	Liquid Crystal Display
LDAP	Lightweight Directory Access Protocol
LEC	LAN Emulation Client

LECS	LAN Emulation Client Server
LED	Light Emitting Diode
LES	LAN Emulation Server
LPWA	Low-Power Wide Area
LTE	Long Term Evolution
LTE-M	Long Term Evolution for Machines
LTE-MTC	LTE optimized for advanced Machine Type Communications
LUN	Logical Unit Numbers
M2M	Machine to Machine
MAC	Media Access Control
MAN	Metropolitan Area Network
MAP	Manufacturing Automation Protocol
MAU	Medium Access Unit
MHS	Message Handling System
MI6	Military Intelligence, Department 6
MIPS	Millions Instructions Per Second
MIT	Massachusetts Institute of Technology
MMU	Memory Management Unit
MP3	MPEG-1 and/or MPEG-2 Audio Layer III
MPLS	Multi Protocol Label Switching
MQTT	Message Queue Telemetry Transport
MRAM	Magnetic Random Access Memory
MTU	Maximum Transmission Unit
NAP	Network Access Point
NAS	Network Attached Storage
NASA	National Aeronautic And Space Administration
NAT	Network Address Translation
NBI	North Bound Interface
NB-IoT	Narrow Band IoT
NCP	Network Control Program
NCR	National Cash Register
NDP	Neighbor Discovery Protocol
NFC	Near Field Communication
NFV	Network Function Virtualization
NIC	Network Interface Card
NLRI	Network Layer Reachability Information
NNI	Network Network Interface
NoSQL	Non Relational Structured Query Language
NSAP	Network Service Access Point
NSCI	National Strategic Computing Initiative
NSF	National Science Foundation
NSFNet	National Science Foundation Network
NSX	VMware NSX Network Virtualization
NVP	Network Virtualization Platform

OAM	Operations Administration Maintenance
OCP	Open Compute Project
ODL	OpenDaylight
OEM	Original Equipment Manufacturer
OMG	Object Management Group
ONF	Open Networking Foundation
ONIE	Open Network Install Environment
ONL	Open Network Linux
OPC	Open Platform Communication
OPEX	Operating Expense
OS	Operating System
OSI	Open Systems Interconnection
OSS	Operational Support System
OT	Operations Technology
OVF	Open Virtualization Format
P2P	Peer to Peer
PAC	Programmable Automation Controller
PC	Personal Computer
PCM	Phase Change Memory
PDH	Plesiochronous Digital Hierarchy
PDU	Protocol Data Unit
PFE	Packet Forwarding Engine
PGP	Pretty Good Privacy
PLC	Programmable Logic Controller
PLS	Physical Layer Signalling
PMA	Physical Medium Attachment
PNNI	Private Network to Network Interface
PSTN	Public Switched Telephone Network
PT	Payload Type
PVC	Permanent Virtual Circuit
QoS	Quality of Service
QuAIL	Quantum Artificial Intelligence Laboratory of NASA
RAID	Redundant Array of Independent Disks
RAM	Random Access Memory
RCA	Radio Corporation of America
RDBMS	Relational Data Base Management System
REST	Representational State Transfer
RFC	Request for Comments
RFID	Radio Frequency IDentification
RIB	Routing Information Base
RISC	Reduced Instruction Set Computing
ROM	Read Only Memory
RSA	Rivest, Shamir and Adleman Encryption
SAN	Storage Area Network

SAP	Systems, Applications, Products
SCADA	Supervisory Control and Data Acquisition
SCV	Smart Connected Vehicle
SD	Secure Digital
SDDC	Software Defined Data Center
SDH	Synchronous Digital Hierarchy
SDK	Software Development Kit
SDN	Software Defined Networking
SDS	Software Defined Storage
SIMD	Single Instruction Multiple Data
SLA	Service Level Agreement
SLAAC	Stateless Address Auto Configuration
SMTP	Simple Mail Transfer Protocol
SNA	Systems Network Architecture
SNIA	Storage Networking Industry Association
SNMP	Simple Network Management Protocol
SOAP	Simple Object Access Protocol
SONET	Synchronous Optical Network
SQL	Structured Query Language
SSH	Secure Shell
SSL	Secure Sockets Layer
STL	Smart Traffic Light
STP	Spanning Tree Protocol
STS	Supranet Transaction Server
STSL	Smart Traffic Light System
STT-RAM	Spin Transfer Torque Random Access Memory
SVC	Switched Virtual Circuit
TCP	Transmission Control Protocol
TCP/IP	Transmission Control Protocol/Internet Protocol
TEPS	Traversed Edges Per Second
TOR	Top Of Rack
TRILL	Transparent Interconnection of Lots of Links
TSN	Time Sensitive Networking
TTL	Time To Live
UCLA	University of California Los Angeles
UDP	User Datagram Protocol
UML	User Mode Linux
UNI	User Network Interface
UNIX	Family of multitasking, multiuser computer operating systems
USENIX	The Advanced Computing Systems Association
UTF-8	UCS (Universal Character Set) Transformation Format
UUCP	Unix-to-Unix-Protocol
VBR	Variable Bit Rate

VC	Virtual Circuit
VCI	Virtual Circuit Identifier
VDS	vSphere Distributed Switch
VDSL	Very High Bit Rate Digital Subscriber Line
VLAN	Virtual LAN
VM	Virtual Machine
VMM	Virtual Machine Monitor
VNI	Visual Networking Index
VP	Virtual Path
VPI	Virtual Path Identifier
VPN	Virtual Private Network
VSS	vSphere Standard Switch
W3C	World Wide Web Consortium
WAN	Wide Area Network
WiFi	Trademark of the WiFi Alliance for wireless local area networking
WLAN	Wireless LAN
WPAN	Wireless Personal Area Network
WPS	Word Processing System
WSAN	Wireless Sensor and Actuator Network
XEN	Linux Foundation Collaboration Projects
Xerox PARC	Xerox Palo Alto Research Center
XML	Extended Markup Language