Inventing the Cloud Century

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How Cloudiness Keeps Changing Our Life, Economy and Technology

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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

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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	Broadcaste 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	Genetecally 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 Langage
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, muktiuser 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