Internet Computing

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Principles of Distributed Systems and Emerging Internet-Based Technologies

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Preface

The Internet is a success story. Over the past few decades, its value to individuals, organizations, and society has become more profound than most of us could ever have imagined. This is no surprise, given that the Internet has brought fundamental changes to almost all areas of life. It has not only changed the way we communicate, gather information, and consume media, but has also led to profound societal changes. Important social debates (e.g., #MeToo) are currently held online, because the Internet provides the required infrastructure and communication channels to allow almost all of our society members to democratically exchange their viewpoints. The Internet's widespread dissemination has also led to new types of companies, purely based on Internet-related business models, emerging. Amazon, Google, and Facebook are famous examples of such companies.

The Internet landscape is still evolving steadily and becoming increasingly complex. This complexity is not only due to the emergence of its underlying infrastructure but also relates to organizations and individuals' more widespread use of the Internet's new and innovative tools. It is therefore extremely important that students and young professionals in the fields related to information technology familiarize themselves with the Internet's basic mechanisms and are introduced to the most promising Internet-related technologies of our time.

Against this backdrop, this book seeks to provide insights into the most important technologies and concepts related to the Internet through the scientific field of Internet computing. It is obviously not possible to cover all facets of Internet computing in a single book; instead, this book's goal is to provide a broad overview of the most important foundational concepts and to shed light on the most promising current trends in Internet computing. In doing so, I primarily take an organizational view and reflect on the importance of the constantly evolving Internet-related architectures and technologies for business issues. For example, the use of cloud-based services has, for organizations of all kinds, become widespread over the last decade. However, with an increasing number of organizations moving toward Industry 4.0 and the Internet of Things, the cloud paradigm may no longer adequately meet some of the emerging demands. Consequently, new paradigms, such as

Fog and Edge Computing, are coming into play and receiving increasing attention from research and practice. Nevertheless, other revolutionary technologies are also closely linked to the Internet and also have the potential to continue the fundamental change driven by the Internet. At the time of writing this book, distributed ledger technologies (e.g., the Bitcoin Blockchain) are just one of such hype topics. Many people presume that distributed ledger technologies' elimination of superfluous third parties could have the potential to lead to profound changes in many areas, such as finance, health, and politics. Whether and to what extent such changes will actually occur remain to be seen. Nevertheless, I believe that such promising developments should be covered and their basics conveyed to the readers of a book such as this.

The idea for this book was raised during discussions with my research associates and PhD students at Karlsruhe Institute of Technology (KIT). While searching for a well-known and respected textbook on Internet computing for one of our lectures, we were surprised to find that no such work existed. Consequently, I decided to write it. This book is divided into 12 chapters, which, as a whole, offer a comprehensive lecture on the foundations of Internet computing. Each individual chapter can be a lecture unit.

My sincerest thanks to all my research associates and PhD students at KIT who helped me create the texts: Tobias Dehling, Malte Greulich, Niclas Kannengießer, Theresa Kromat, Sebastian Lins, Benjamin Sturm, Heiner Teigeler, and Scott Thiebes. I specifically want to thank Manuel Schmidt-Kraepelin, who not only helped me create the book's content but also supported me during the publication process. I would also like to thank Elisabeth Lieder for supporting the project at the operational level and Deniz Özdem for creating the graphics. I also want to thank Ilse Evertse and her associates for the editing of this book

I hope that you enjoy reading about, getting to know the many new aspects of Internet computing, and experiencing its fascination. We are responsible for the Internet's future—not only by providing its technological advances but also by finding innovative ways of generating value for individuals, organizations, and societies alike. Let us take on this responsibility together.

Last but not least, the author is responsible for all the formal and content errors.

Karlsruhe, Germany Ali Sunyaev

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Abbreviations

ADD	Attribute-driven design
AED	Automated external defibrillator
AFRINIC	African Network Information Center
AGI	Artificial general intelligence
AI	Artificial intelligence
Amazon S3	Amazon Simple Storage Service
AMQP	Advanced Message Queuing Protocol
ANI	Artificial narrow intelligence
API	Application programming interface
APNIC	Asia-Pacific Network Information Centre
AR	Augmented reality
ARIN	American Registry for Internet Numbers
ARP	Address Resolution Protocol
ARPA	Advanced Research Project Agency
ASI	Artificial super intelligence
ASR	Architecturally significant requirements
AV	Augmented virtuality
AWS	Amazon Web Services
B2B	Business-to-business
B2C	Business-to-consumer
BBN	Bolt, Beranek, and Newman
BOT	Beginning of transaction
BTC	Bitcoin
CA	Certification authority
CAVE	Cave automatic virtual environment
CCN	Content-centric networking
CDC	Centers for Disease Control and Prevention
CDN	Content delivery network
CGM	Continuous glucose monitoring
CICS	Customer Information and Control Systems
CII	Critical information infrastructure

CIX	Commercial Internet eXchange
CLR	Common Language Runtime
COM	Component Object Model
COMPAS	Correctional Offender Management Profiling for Alternative Sanctions
CORBA	Common Object Request Broker Architecture
CRL	Certification revocation list
CRM	Customer relationship management
CSC	Cloud service certification
CSNET	Computer Science Network
CSS	Cascading Style Sheets
DARPA	Defense Advanced Research Projects Agency
DCE	Distributed Computing Environment
DCOM	Distributed Component Object Model
DCPS	Data-Centric Publish/Subscribe
DDoS	Distributed denial of service
DII	Dynamic Invocation Interface
DLRL	Data Local Reconstruction Layer
DLT	Distributed Ledger Technology
DNS	Domain name system
DOE	Department of Energy
DoS	Denial-of-Service
DPoS	*Delegated Proof-of-Stake*
DRE	Direct-recording electronic
DSI	Dynamic Skeleton Interface
EAI	Enterprise Application Integration
EAS	Emergency Alert System
EHR	Electronic health record
EOT	End of transaction
EPA	Environmental Protection Agency
ESIOP	Environment-Specific Inter-ORB Protocol
ESNet	Energy Sciences Network
ETSI	European Telecommunications Standards Institute
EU	European Union
EVM	Ethereum Virtual Machine
FCC	Federal Communications Commission
FDDI	Fiber Distributed Data Interface
FEMA	Federal Emergency Agency
FId	Forwarding identifier
FTP	File Transfer Protocol
GIOP	General Inter-ORB Protocol
GP	General practitioner
GPS	Global Positioning System
GTP	Game transfer phenomena

HLL	High-level programming language
HMD	Head-mounted display
HTML	HyperText Markup Language
HTTP	HyperText Transfer Protocol
IaaS	Infrastructure as a Service
IAB	Internet Architecture Board
ICANN	Internet Corporation for Assigned Names and Numbers
ICCC	International Computer Communications Conference
ICMP	Internet Control Message Protocol
ICN	Information-centric networking
ICO	Initial coin offering
ICT	Information and communication technology
IDE	Integrated development environment
IDL	Interface definition language
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IGMP	Internet Group Management Protocol
IGRP	Interior Gateway Routing Protocol
IIN	Interbank Information Network
IIOP	Internet Inter-ORB Protocol
IMP	Interface Message Processor
IoT	Internet of Things
IP	Internet Protocol
IPTO	Information Processing Technique Office
IRTF	Internet Research Task Force
IS	Information systems
ISO	International Organization for Standardization
ISOC	Internet Society
ISP	Internet Service Provider
IT	Information technology
ITU	International Telecommunication Union
IXP	Internet Exchange Point
J2SE	Java 2 Standard Edition
Java EE	Java Platform Enterprise Edition
JMS	Java Messaging Service
JSON	*JavaScript Object Notation*
LACNIC	Latin America and Caribbean Network Information Centre
LAN	Local Area Network
LBS	location-based service
LCD	Liquid crystal display
LPC	Local procedure call
MAE	Metropolitan Area Exchange
MOM	Message-oriented middleware
MQTT	Message Queuing Telemetry Transport
MR	Mixed reality

MTBF	Mean time between failure
MTS	Microsoft Transaction Server
MTTR	Mean time to repair
MTU	Maximum transmission unit
MVC	Model View Controller
NAP	Network Access Point
NASA	National Aeronautics and Space Administration
NCP	Network Control Program
NFS	Network File System
NFV	Network function virtualization
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NPL	National Physical Laboratory
NSF	National Science Foundation
OMG DDS	Data Distribution Service by the Object Management Group
OOM	Object-oriented middleware
ORB	Object Request Broker
OSI	Open Systems Interconnection
P2P	Peer-to-peer
PaaS	Platform as a Service
PBFT	Practical Byzantine fault tolerance
PC	Personal Computer
PDA	Personal digital assistant
PIT	Pending interest table
POA	Portable Object Adapter
POP	Point of presence
POP3	Post Office Protocol 3
PoS	*Proof-of-Stake*
PoW	Proof of Work
PSIRP	Publish-Subscribe Internet Routing Paradigm
PSMOM	Publish/subscribe message-oriented middleware
QoS	Quality of service
RA	Registration authority
RARP	Reverse Address Resolution Protocol
REST	Representational State Transfer
RFC	Request for Comments
RFID	Radio frequency identification
RId	Rendezvous identifier
RIP	Routing Information Protocol
RIPE NCC	Réseaux IP Européens Network Coordination Centre
RIR	Regional Internet Registries
RMI	Remote Method Invocation
RSM	*Replicated state machine*
SaaS	Software as a Service

SAML	Security Assertion Markup Language
SCADA	Supervisory control and data acquisition
SCTP	Stream Control Transmission Protocol
SDN	Software-defined networking
SGML	Standard Generalized Markup Language
SHA	Secure hash algorithm
SId	Scope identifier
SLA	Service-level agreements
SMTP	Simple Mail Transfer Protocol
SNMP	Simple Network Management Protocol
SOA	Service-oriented architecture
SOAP	Simple Object Access Protocol
SQS	Amazon Simple Queue Service
SRI	Stanford Research Institute
SSL	Secure Sockets Layer
STOMP	Streaming Text-Oriented Messaging Protocol
SUS	System Usability Scale
TCP	Transmission Control Protocol
TDAG	Transaction-based directed acyclic graphs
TIP	Terminal Interface Processor
TLS	Transport Layer Security
TOM	Transaction-oriented middleware
TP	Transaction processing
TRPC	Transactional remote procedure call
TTL	Time to live
UCLA	University of California, Los Angeles
UCSB	University of California, Santa Barbara
UDP	User Datagram Protocol
UID	Unique identifier
UML	Unified Model Language
URI	Uniform Resource Identifiers
UTXO	Unspent transaction output
VC	Venture capital
VNF	Virtualized network function
VoIP	Voice over IP
VPN	Virtual private network
VR	Virtual reality
W3C	World Wide Web Consortium
WADL	Web Application Description Language
WAL	Write-ahead log
WAN	Wide Area Network
WCF	Windows Communication Foundation
WHO	World Health Organization
WSAN	Wireless sensor and actuator network

WS-BPEL	Web Services Business Process Execution Language
WSDL	Web Services Description Language
WSN	Wireless sensor network
WWW	World Wide Web
XaaS	Everything as a Service
XML	Extensible Markup Language
XSD	XML Schema Definition