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Christoph Meinel · Harald Sack

Internetworking

Technological Foundations and Applications

 Springer

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ISSN 1612-1449

ISBN 978-3-642-35391-8

ISBN 978-3-642-35392-5 (eBook)

DOI 10.1007/978-3-642-35392-5

Springer Heidelberg New York Dordrecht London

Library of Congress Control Number: 2013947814

Translation from the German language edition: *Internetworking. Technische Grundlagen und Anwendungen*. © Springer Berlin Heidelberg 2012.

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Preface

What should still be something pretty amazing seems just like a part of everyday life to a lot of people. In recent decades, the old dream driving human development toward a mobility spanning time and space has become unprecedented reality. And this without a single physical law being broken. Instead we have learned to deal with a surprising number of things in life in a dematerialized, digitalized form. Dematerialized in the sense that instead of confronting the things themselves directly we interact with their digital "shadows." In essence, their descriptions, which are coded in the form of zeros and ones and then transported at the speed of light via electromagnetic signals to be processed at any computer. Two technological developments have made this possible. First, computers in all their forms provide the cosmos to give these digital shadows complete expression. Here, they can be realized anew, processed, linked and stored. Second, the Internet offers the possibility of transporting the digital shadows almost anywhere in the world at the speed of light where they achieve their full effect at another computer, even if it's at the other end of the world.

In fact, the computer and Internet rank among those very few technological developments in human history that have intrinsically changed people's lives and actions. The industrial revolution of the 19th and 20th centuries expanded our physical mobility in way that had been unparalleled up to that time. Just as cars, airplanes and space ships have dramatically increased the radius of human physical activity, the drivers of the digital revolution - computers and Internet technology - have extended our intellectual mobility in a way that was previously unthinkable. Our range of mental activity has been freed from (almost) every physical limitation. While it is likely that even the most modern physical transportation medium will still need some hours to bring a person from one continent to another, he or she is now able to bridge this distance almost immediately with the help of the Internet. Feelings, thoughts and instructions can be sent within seconds as we respond to the wishes and needs of those far away. And in contrast to physical transportation this can be done without significant cost.

The Internet is not even 50 and the WWW a good 20 years old - a young and ongoing history, with the rapid developments in computer and network technology continuing unabated. This makes it all the more interesting to look behind the scenes and gain an understanding of the technical basics of how the Internet and the WWW really work. This is just what "Internetworking" has set out to do. Together with this trilogy's two other volumes, "Digital Communication" and "Web Technologies," we aim to offer the reader an understandable, comprehensive, trustworthy, informative and detailed guide.

The specific concepts presented in volume 1 of the trilogy, "Foundations of Digital Communication," (computer networks, media and their coding, communication

protocols and security in computer networks) form the basis for the book at hand, volume 2, "Internetworking." Against the background of the developmental history of the Internet and a short guide through the Internet with its various actors, the actual functioning of Internet technology - the TCP/IP protocol stack - is introduced. We will look in detail at the physical layer required for every digital communication, as well as at the network access layer with its numerous technologies - wireless LAN, wired LAN, WAN. Attention will be given to the Internet layer with the protocols that support the Internet: IPv4, IPv6 and Mobile IP and the transport layer with the second protocol of the Internet - the eponymous TCP, as well as the application layer with its multi-faceted Internet services that have helped the Internet achieve its revolutionary significance for today's society. Only the World Wide Web has been excluded here and will be examined on its own in the third volume, "Web Technologies." Underlying Web technologies, such as URL, HTTP, HTML, CSS, XML, web programming, search engines, Web2.0 and the Semantic Web are presented in detail there.

The multi-dimensional material, containing understandable descriptions complemented by numerous, technically detailed excursus and glossaries offering chapter-related commentaries, indexes and bibliographic references, is arranged in such a way as to be an invitation for further research and reading. The reader is assisted in gaining the easiest access possible to the fullness of available material and also guided in making an interest or topic-based selection.

We have gone to great lengths in the hope that those of you who are interested laypeople will be infected by the fascination of the new digital world offered in this book. We also aim to provide hard-working students - who don't shy away from a bit of extra effort - with a useful and comprehensive textbook. Furthermore, we would like to present readers who are seasoned professionals with a reliable, handy reference book that can serve to classify areas of specialization easily and safely within the context of the huge complex of digital communication.

Many thanks to our colleagues at the Hasso Plattner Institute, "Department of Internet Systems and Technologies" for every imaginable support in research and teaching, as well as to Springer Verlag in the person of Hermann Engesser and Dorothea Glaunsinger for their trust in the success of this book project and their patience in its realization, and to Ivana and Anja for the forbearance and tolerance shown when we each disappeared into the office on countless weekends and holidays and for your love which accompanied us there.

Potsdam, August 2013

*Christoph Meinel
Harald Sack*

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Chapter 1

Prologue

"Read quickly, because nothing is more certain than change on the Internet!"

– Anita Berres (German journalist)

Digital communication has developed into one of the driving technical and cultural forces in the 21st century. More than ever has it become impossible to imagine living in today's world without the Internet as our universal communication medium. In the first volume of this series the focus was on the general foundation of digital communication, i.e., the basics of computer networking, media encoding technology and digital security. In this volume, the Internet, with its various contributors, technological foundation and numerous protocols and technologies, will be covered.

The computer and the Internet belong to the group of rare technological developments in the history of humankind that have changed the life and actions of people in a fundamental way. As a driving force of the digital revolution it has expanded our intellectual mobility to a degree that would have been inconceivable in the past, and freed our mental radius of action from (nearly) every physical limitation. Together with the other volumes of this series, "Fundamentals of Digital Communication" and "Web Technologies", this book serves as a comprehensive and instructive guide through the world of modern, digital communication. This present volume could be considered the heart of the series, in which the basic technological and functional principles of the communication infrastructure of the Internet are described in detail.

A short historical look back at almost 50 years of Internet history starts off the prologue, introducing the key participants and their tasks in the global Internet.

The communication tasks taken on by the Internet are enormously complex. Various computer architectures, based on local need, connect networks of different dimensions and technologies into a virtual communication network. The user is, at the same time, always given the impression that the resulting Internet is in fact a unified and homogeneous entity. In order to master this monumental complexity, a hierarchical, modular approach was chosen in the form of a communication layer model. This has the added benefit that the tasks to be carried out at each layer are self-contained and the interaction between these layers proceeds over a fixed interface. Chapter 2