3G, 4G AND BEYOND—BRINGING NETWORKS, DEVICES AND THE WEB TOGETHER
3G, 4G AND BEYOND–BRINGING NETWORKS, DEVICES AND THE WEB TOGETHER

Second Edition

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In recent years, cellular voice networks have transformed into powerful packet-switched access networks for both voice communication and Internet access. Evolving Universal Mobile Telecommunication System (UMTS) networks and first Long Term Evolution (LTE) installations now deliver bandwidths of several megabits per second to individual users, and mobile access to the Internet from handheld devices and notebooks is no longer perceived as slower than a Digital Subscriber Line (DSL) or cable connection. Bandwidth and capacity demands, however, keep rising because of the increasing number of people using the networks and because of bandwidth-intensive applications such as video streaming. Thus, network manufacturers and network operators need to find ways to continuously increase the capacity and performance of their cellular networks while reducing the cost.

In the past, network evolution mainly involved designing access networks with more bandwidth and capacity. As we go beyond 3G network architectures, there is now also an accelerated evolution of core networks and, most importantly, user devices and applications. This evolution follows the trends that are already in full swing in the “fixed-line” Internet world today. Circuit-switched voice telephony is being replaced by voice over IP technologies, and Web 2.0 has empowered consumers to become creators, to communicate with their friends and to share their own information with a worldwide audience. With connected smartphones having become a mainstream phenomenon in recent years, they will have a major impact on this trend, as they are an ideal tool for creating and consuming content. The majority of mobile phones today have advanced camera and video capabilities, and together with fast wireless access technologies, it has become possible to share information with others instantly.

While all these trends are already occurring, few resources are available that describe them from a technical perspective. This book therefore aims to introduce the technology behind this evolution. Chapter 1 gives an overview of how mobile networks have evolved in the past and what trends are emerging today. Chapter 2 then takes a look at radio access technologies such as High-Speed Packet Access (HSPA+), LTE, and the evolution of the Wi-Fi standard. Despite the many enhancements next-generation radio systems will bring, bandwidth on the air interface is still the limiting factor. Chapter 3 takes a look at the performance of next-generation systems in comparison to today’s networks, shows where the limits are, and discusses how Wi-Fi can help to ensure future networks can meet the rising demand for bandwidth and integrated home networking. Voice over IP is already widely used in fixed line networks today, and “Beyond 3G” networks have enough capacity
and performance to bring about this change in the wireless world as well. Chapter 4 thus focuses on Voice over IP architectures, such as the IP Multimedia Subsystem (IMS) and the Session Initiation Protocol (SIP) and discusses the impacts of these systems on future voice and multimedia communication. Just as important as wireless networks are the mobile devices using them, and Chapter 5 gives an overview of current mobile device architectures and their evolution. Finally, mobile devices are only as useful as the applications running on them. So Chapter 6 discusses how “mobile Web 2.0” applications and native apps are changing the way we communicate today and in the future.

Since the publication of the first edition of this book, many predictions have become a reality and new challenges and opportunities have arisen. While LTE was only on the distant horizon when the first edition was published, it is a reality today, and HSPA networks have undergone significant evolution as well. New spectrum bands have been assigned and auctioned in the meantime and many network operators around the globe have since made use of them to increase the coverage and capacity of their networks. Perhaps the biggest evolution over the past five years has been on the mobile device side. Mobile operating systems dominating the market only a few years ago have almost vanished and new entrants such as Android and iOS have taken the mobile world by storm. And finally on the web and application programming side, significant advances triggered an update of this chapter as well. As a consequence, about half the content of the previous edition of this book was updated or entirely rewritten to reflect the current state of the art and to give an outlook of what is to come in the next five years.

No book is written in isolation and many of the ideas that have gone into this manuscript are the result of countless conversations over the years with people from across the industry. Specifically, I would like to thank Debby Maxwell, Prashant John, Kevin Wriston, Peter van den Broek, and John Edwards for the many insights they have provided to me over the years in their areas of expertise and for their generous help with reviewing the manuscript. A special thank you goes to Berenike for her love, her passion for life, and for inspiring me to always go one step further. And last but not least I would like to thank Mark Hammond, Susan Barclay, and Sandra Grayson of John Wiley & Sons for the invaluable advice they gave me throughout this and previous projects.
1

Evolution from 2G over 3G to 4G

In the past 20 years, fixed line and wireless telecommunication as well as the Internet have developed both very quickly and very slowly depending on how one looks at the domain. To set current and future developments into perspective, the first chapter of this book gives a short overview of major events that have shaped these three sectors in the previous two decades. While the majority of the developments described below took place in most high-tech countries, local factors, and national regulation delayed or accelerated events. Therefore, the time frame is split up into a number of periods and specific dates are only given for country-specific examples.

1.1 First Half of the 1990s — Voice-Centric Communication

Twenty years ago, in 1993, Internet access was not widespread and most users were either studying or working at universities or in a few select companies in the IT industry. At this time, whole universities were connected to the Internet with a data rate of 9.6 kbit/s. Users had computers at home but dial-up to the university network was not yet widely used. Distributed bulletin board networks such as the Fidonet [1] were in widespread use by the few people who were online then.

It can therefore be said that telecommunication 20 years ago was mainly voice-centric from a mass market point of view. An online telecom news magazine [2] gives a number of interesting figures on pricing around that time, when the telecom monopolies were still in place in most European countries. A 10-min “long-distance” call in Germany during office hours, for example, cost €3.25.

On the wireless side, first-generation analog networks had been in place for a number of years, but their use was even more expensive and mobile devices were bulky and unaffordable except for business users. In 1992, GSM networks had been launched in a number of European countries, but only few people noticed the launch of these networks.

1.2 Between 1995 and 2000: The Rise of Mobility and the Internet

Around 1998, telecom monopolies came to an end in many countries in Europe. At the time, many alternative operators were preparing themselves for the end of the monopoly and prices went down significantly in the first week and months after the new regulation...