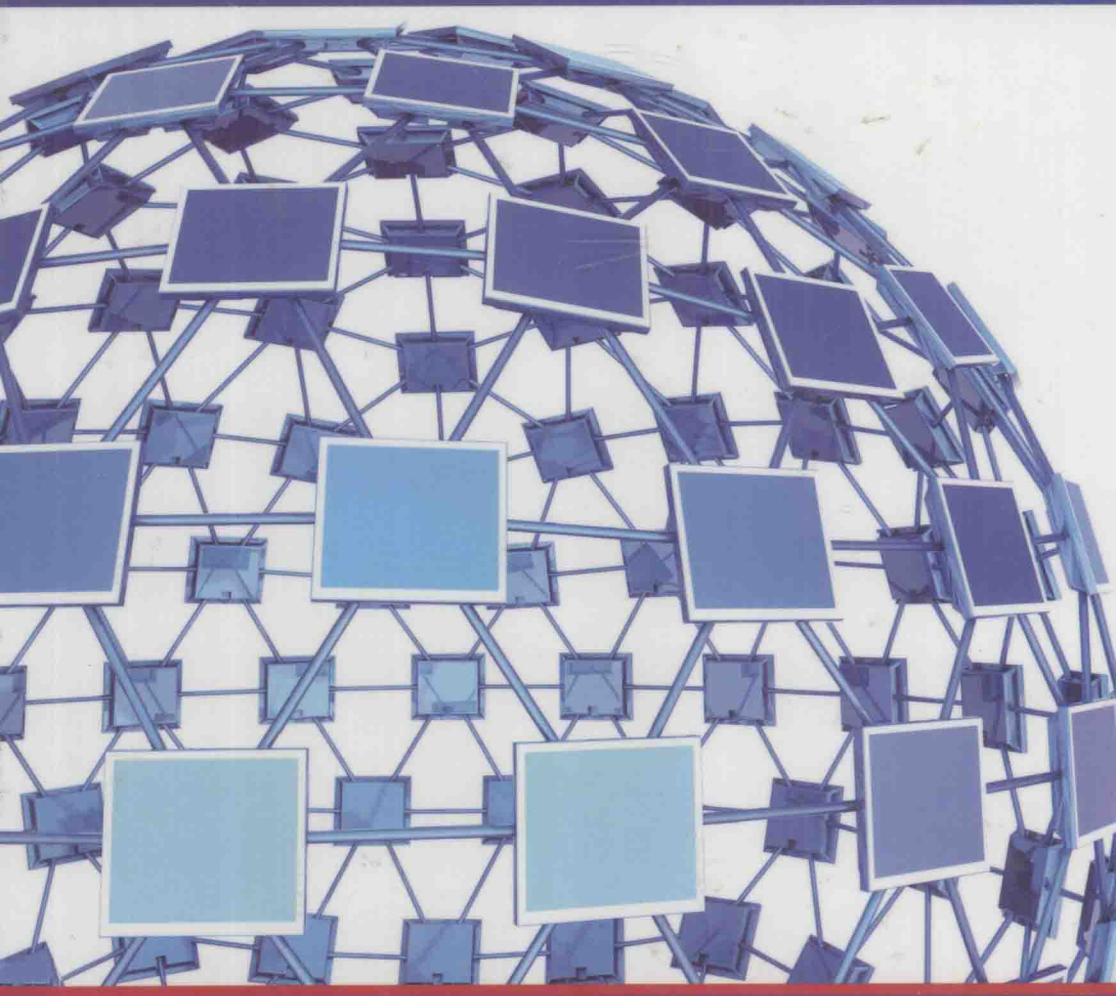
Transmission Techniques for Emergent Multicast and Broadcast Systems

Mário Marques da Silva, Américo M. C. Correia, Rui Dinis, Nuno Souto, and João Carlos Silva



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CRC Press
Taylor & Francis Group
Boca Raton London New York

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AN AUERBACH BOOK

Auerbach Publications
Taylor & Francis Group
6000 Broken Sound Parkway NW, Suite 300
Boca Raton, FL 33487-2742

Auerbach Publications is an imprint of Taylor & Francis Group, an Informa business

Printed in the United States of America on acid-free paper
10 9 8 7 6 5 4 3 2 1

International Standard Book Number: 978-1-4398-1593-9 (Hardback)

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Preface

This book presents a detailed and comprehensive description of the most important enhancements from a requirements perspective, transmission techniques, and receiver designs using multiresolution schemes for modern broadband wireless systems. It covers several hot topics that are key in the development of emergent services. In order to support the requirements of new services, this book addresses the means that allow increasing the bit rate per user and, as a result, increasing the capacity of digital cellular radio networks due to improved spectral efficiency.

The purpose of this book is to concentrate in a single place several important research and development (R&D) activities currently taking place in the field of wireless communications for multimedia broadcast and multicast service (MBMS). These aspects are normally split into different references, and thus the proposed book reduces the time and cost required to learn and improve skills and knowledge in the field. Moreover, this book presents a compilation of the latest developments in the area that is the outcome of several years of research and participation in many international activities and projects. The focus is on the key requirements of emergent services, with a special emphasis on the MBMS. The purpose is to cover several subjects that allow reaching such key requirements, providing the corresponding description of fundamentals and theory.

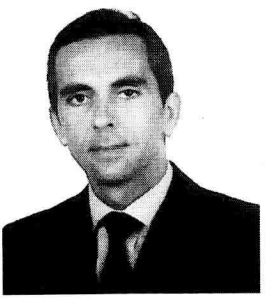
The transmission, detection techniques, and schemes presented in this book are relevant to many digital communication systems (wireless, cellular, satellite, etc.). Nevertheless, a special focus is placed on the multimedia services using multicast and broadcast techniques, which is the main subject of this book.

With such an approach, this book covers a wide range of potential readers: it can be used either by an engineer with a BSc degree to learn more about the latest R&D wireless activities for the purpose of an MSc or PhD program, or for business activities; this book can also be used by academic, institutional, or industrial researchers in order to support the study, planning, design and development of prototypes and systems.

Although the subjects associated with MBMS covered in this book are wide and generic, applicable to unicast, multicast, and broadcast, the final and concluding chapter focuses on a system-level evaluation of MBMS using different transmission techniques. Owing to the demanding Quality-of-Service requirements (bandwidth, bit error rate,

capacity, latency, jitter packet loss, etc.), in order to allow the deployment of the emergent services, such as video broadcast, HDTV over the Internet, video-on-demand, mobile television, and so on, several enhancements to MBMS were introduced. The combination of the enhancements is accomplished by adaptive transmission techniques. The concluding chapter of this book presents the combination of these techniques and enhancements for the purpose of implementing the evolved MBMS (E-MBMS).

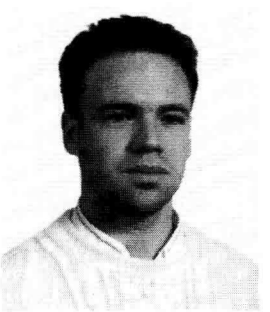
Authors



Mário Marques da Silva [marques.silva@ieee.org] is a researcher at the Portuguese Instituto de Telecomunicações (Institute for Telecomunications) and the Centro de Estudos em Sistemas de Informação e Tecnologias Informáticas (CESITI). He is a professor at the Universidade the Autónoma de Lisboa and leads an Engineering Branch at Information Technologies and Telecommunications Directorate, Portuguese Navy. He received his BSc in electrical engineering in 1992, and MSc and PhD degrees in electrical engineering and mobile communications, respectively, in 1999 and 2005, both from the Instituto Superior Técnico, Technical University of Lisbon, Portugal.

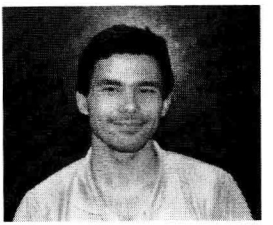
Between 2005 and 2008, he was with the NATO Air Command Control Management Agency (NACMA) in Brussels, Belgium, where he managed the deployable communications of the new Air Command and Control System Program. He has been involved in several telecommunications projects, either as a researcher or project leader, including research, architecture, development, analysis, simulation and testing of networking, HF, V/UHF, satellite and cellular/UMTS communications systems. He is the author of more than 30 papers and a reviewer of several international publications including journals and conferences. He is a member of the Institute of Electrical and Electronics Engineers (IEEE) and the Armed Forces Communications and Electronics Association (AFCEA). His research interests include networking (e.g., mobile ad hoc networking, TCP/IP) and mobile communications, including block transmission techniques (OFDM, SC-FDE), WCDMA, multiuser detection, interference cancelation, space–time coding, MIMO systems, smart and adaptive antennas, channel estimation, and software-defined radio.

Américo M.C. Correia received his BSc degree in electrical engineering from the University of Angola in 1983, and his MSc and PhD degrees from the Instituto Superior Técnico (IST-UTL), Lisbon, Portugal, in 1990 and 1994, respectively. From 1991 to 1999 he was with IST as an assistant professor. He is currently a full professor with the Instituto Superior de Ciências do Trabalho e da Empresa (ISCTE-IUL), Lisbon, Portugal. He visited the Nokia Research Center from September to December 1998 as a visiting scientist. From September 2000 to August 2001 he worked for Ericsson EurolabNetherlands. His current research topics include wideband CDMA, OFDMA, MIMO, radio resource management, and multimedia broadcast/multicast services.



Rui Dinis received his PhD degree from the Instituto Superior Técnico (IST), Technical University of Lisbon, Portugal, in 2001. From 2001 to 2008 he was a professor at IST. Since 2008 he has been teaching at FCT-UNL (Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa). He was a researcher at the Centro de Análise e Processamento de Sinais (CAPS)/IST from 1992 to 2005; from 2005 to 2008 he was researcher at ISR/IST (Instituto de Sistemas e Robótica); and in 2009 he joined the research IT center (Instituto de Telecomunicações).

Nuno Souto graduated in aerospace engineering–avionics branch in 2000 from the Instituto Superior Técnico, Lisbon, Portugal. From November 2000 to January 2002 he worked as a researcher in the field of automatic speech recognition for the Instituto de Engenharia e Sistemas de Computadores, Lisbon, Portugal. He received his PhD in electrical engineering from the Instituto Superior Técnico in 2006. He currently works as an assistant professor at the Instituto Superior de Ciências do Trabalho e da Empresa (ISCTE), Lisbon, Portugal. He has participated in several European research projects and has published several articles in international journals. His research interests include wideband CDMA systems, OFDM, channel coding, modulation, channel estimation, and MIMO systems.



João Carlos Silva received his BS degree in aerospace engineering from the Instituto Superior Técnico (IST), Lisbon Technical University, in 2000. From 2000 to 2002 he worked as a business consultant for McKinsey & Company. He also completed his PhD thesis at IST in 2006, focusing on spread spectrum techniques, multiuser detection schemes, and MIMO systems. From 2006 to 2007 he was a professor at the Escola Superior Tecnologia e Gestão (ESTG) in Leiria (teaching physics and electronics), and has been a professor since 2007 at the Instituto Superior de Ciencias do Trabalho e da Empresa (ISCTE), in Lisbon (teaching computer networks). He is the author of more than 40 papers and a reviewer of several international publications. His research interests include computer networks and mobile communications, such as block transmission techniques (OFDM, SC-FDE), WCDMA, multiuser detection, interference cancelation, space–time coding, MIMO systems, smart and adaptive antennas, channel estimation, and software-defined radio.

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Chapter 1

Introduction

Future wireless systems will be (IP) internet protocol-based and will provide acceptable quality of service (QoS) in terms of speed, bit error rate (BER), end-to-end packet loss, jitter, and delays for different types of traffic. Many technological achievements were made in the last few years in the area of communications and others are planned for the future to allow new, emergent, and future services. Whereas in the past, new technologies pushed new services, today reality can be the opposite: end users want services to be employed on a day-to-day basis, whatever the technology supporting it. Users want to browse the Internet, have e-mail access chat, and establish a video conference session, regardless of the technology used (e.g., WiMAX, Wi-Fi, 3G, HSPA, etc.). It is most important to have the required/desired service available, and with quality. Thus, services must be delivered following the concept of "anywhere" and "anytime." Figure 1.1 presents the bandwidth (BW) requirements for each different service.

Multimedia broadcast and multicast service (MBMS) is intended to use spectrum-efficient multimedia services, such as video broadcast or mobile television (by transmitting data over a common radio channel), both in the core network and, above all, in the air interface, where the bottleneck in terms of spectrum efficiency is placed to a large group of users. MBMS allows downlink data to be transmitted from a single source to multiple recipients in broadcast or multicast modes and can be offered via existing global system for mobile communication (GSM) and universal mobile telecommunications system (UMTS) cellular networks. In addition, MBMS includes point-to-point (PtP) and point-to-multipoint (PMP) modes. Whereas the former allows individual retransmissions, the latter does not.

1.1 Requirements for MBMSs

There is still a lot of ongoing investigation on ways of improving the delivery of multimedia information. The multimedia paradigm has put pressure on resources optimization, and sharing channels is one of the most important aspects in network optimization. Efficient network resource usage should be the leverage for upcoming multimedia applications. Besides this, in order to guarantee scalability, multiresolution schemes have to be considered in current UMTS and emergent cellular standards.

One of the most important properties of MBMS is resource sharing among many user equipments (UEs). This means that many users should be able to listen to the same MBMS channel, at the same time. Therefore, power should be allocated to these MBMS channels for arbitrary UEs in the cell to receive this service. This approach goes against the traditional power control concept used in unicast, where the power should be controlled to provide the required QoS [typically a minimum signal to noise ratio (SNR)] to a user located at the edge of the cell, while avoiding high interference levels to users in the same cell or in adjacent cells.

Services may be classified by the type of cast, namely unicast, multicast, or broadcast. In unicast, a single source transmits the data to a single destination. Multicast service consists of a node that sends the same content to multiple (specific) destinations. In wireless medium, broadcast is the basic mode, as the data are sent to all nodes. MBMS is a system that enables mobile networks to efficiently deliver data from a single content

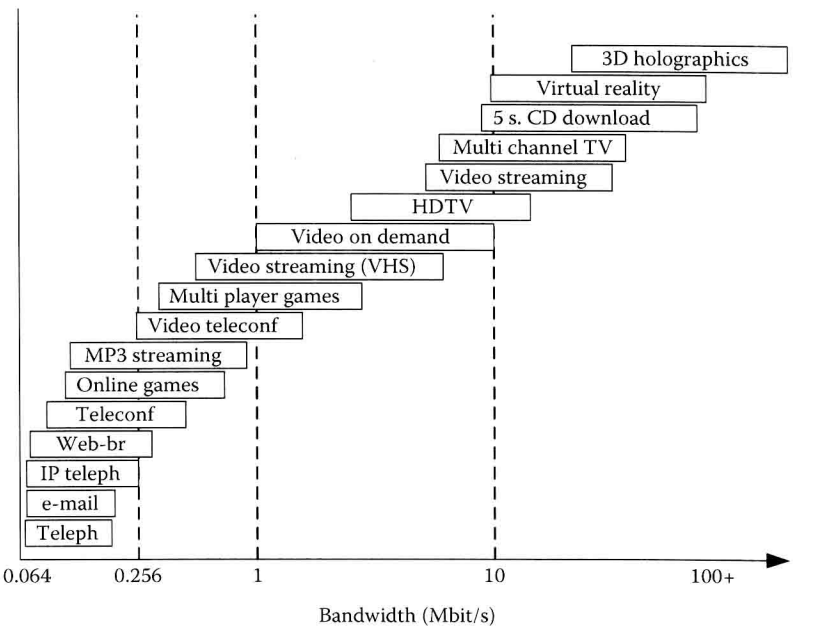

Figure 1.1 BW requirements of the different services.

provider source to multiple users by sharing radio and transport network resources. Multimedia services can be delivered in either multicast or broadcast mode. In multicast mode multimedia data can be transmitted to a specific group of users (MBMS user groups) in a specific area (MBMS service area). In broadcast mode data are transmitted in a specific area (MBMS service area), but all users in the specific MBMS service area will be able to receive the transmitted MBMS data.

For broadcast and multicast transmissions in a mobile cellular network, depending on the communication link conditions some receivers will have better SNR than others, and thus the capacity of the communication link for these users is higher. In broadcast transmissions, it is possible to exchange some of the capacity of the good communication links to the poor ones and the trade-off can be worthwhile. Figure 1.2 shows typical cellular topology, where a Node B (i.e., a BS) is the central node of each cell.

The specific feature for multiresolution consists of Fast Link Adaptation: instead of compensating the variations of downlink radio conditions by means of power control, the transmitted power is kept constant and the modulation and coding of the transport block are chosen at every transmission time interval (TTI). This is called adaptive modulation

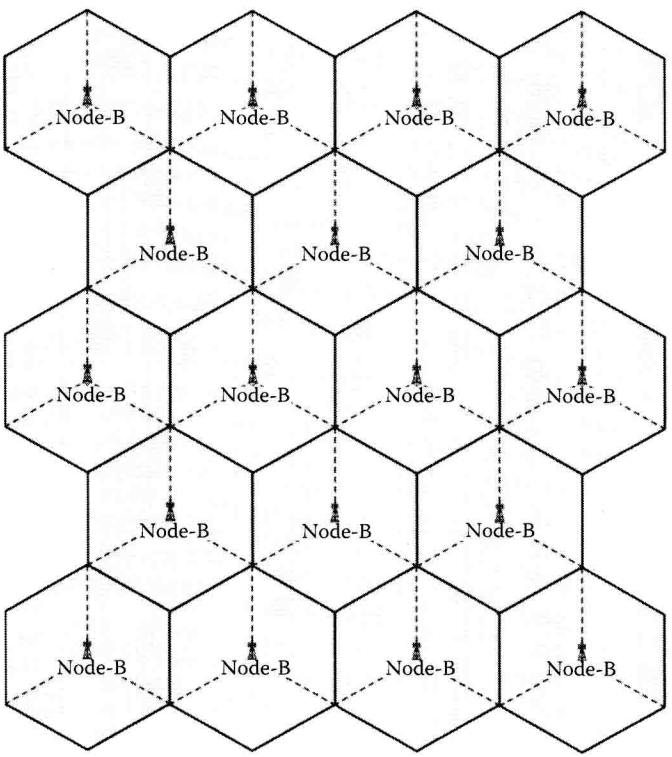

Figure 1.2 Typical cellular topology.