

 WILEY



# LTE for UMTS

## Evolution to LTE-Advanced

SECOND EDITION

Harri Holma  
and Antti Toskala



IPR2022-00457

**DOCKET**  
**ALARM**

Find authenticated court documents without watermarks at [docketalarm.com](https://docketalarm.com).

# LTE for UMTS

## Evolution to LTE-Advanced

### Second Edition

Edited by

**Harri Holma and Antti Toskala**

Nokia Siemens Networks, Finland



A John Wiley and Sons, Ltd., Publication

IPR2022-00457

This edition first published 2011  
© 2011 John Wiley & Sons, Ltd

*Registered office*

John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, United Kingdom

For details of our global editorial offices, for customer services and for information about how to apply for permission to reuse the copyright material in this book please see our website at [www.wiley.com](http://www.wiley.com).

The right of the author to be identified as the author of this work has been asserted in accordance with the Copyright, Designs and Patents Act 1988.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, except as permitted by the UK Copyright, Designs and Patents Act 1988, without the prior permission of the publisher.

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic books.

Designations used by companies to distinguish their products are often claimed as trademarks. All brand names and product names used in this book are trade names, service marks, trademarks or registered trademarks of their respective owners. The publisher is not associated with any product or vendor mentioned in this book. This publication is designed to provide accurate and authoritative information in regard to the subject matter covered. It is sold on the understanding that the publisher is not engaged in rendering professional services. If professional advice or other expert assistance is required, the services of a competent professional should be sought.

*Library of Congress Cataloging-in-Publication Data*

LTE for UMTS : Evolution to LTE-Advanced / edited by Harri Holma, Antti Toskala. – Second Edition.  
p. cm

Includes bibliographical references and index.

ISBN 978-0-470-66000-3 (hardback)

1. Universal Mobile Telecommunications System. 2. Wireless communication systems – Standards. 3. Mobile communication systems – Standards. 4. Global system for mobile communications. 5. Long-Term Evolution (Telecommunications) I. Holma, Harri (Harri Kalevi), 1970-II. Toskala, Antti. III. Title: Long Term Evolution for Universal Mobile Telecommunications Systems.

TK5103.4883.L78 2011

621.3845'6 – dc22

2010050375

A catalogue record for this book is available from the British Library.

Print ISBN: 9780470660003 (H/B)

ePDF ISBN: 9781119992950

oBook ISBN: 9781119992943

ePub ISBN: 9781119992936

Typeset in 10/12 Times by Laserwords Private Limited, Chennai, India.

IPR2022-00457

# 5

## Physical Layer

Antti Toskala, Timo Lunttila, Esa Tiirola, Kari Hooli, Mieszko Chmiel and Juha Korhonen

### 5.1 Introduction

This chapter describes the physical layer of LTE, based on the use of OFDMA and SC-FDMA principles as covered in Chapter 4. The LTE physical layer is characterized by the design principle of not reserving dedicated resources for a single user; resource usage is based solely on dynamically allocated shared resources. This is analogous to resource usage in the internet, which is packet based without user-specific resource allocation. The physical layer of a radio access system has a key role of defining the resulting capacity and ends up being a focal point when comparing different systems in terms of expected performance. However, a competitive system requires an efficient protocol layer to ensure good performance all the way to the application layer and to the end user. The flat architecture adopted, covered in Chapter 3, also enables the dynamic nature of the radio interface as all radio resource control is located close to the radio in the base-station site. The 3GPP term for the base station used in rest of this chapter will be ‘eNodeB’ (similar to the WCDMA BTS term, which is ‘Node B’, where ‘e’ stands for ‘evolved’). This chapter first covers the physical channel structures and then introduces the channel coding and physical layer procedures. The chapter concludes with a description of physical layer measurements and device capabilities as well as with a brief look at physical layer parameter configuration aspects. In 3GPP specifications the physical layer was covered in the 36.2 series, with the four key physical layer specifications being [1–4]. Many of the issues in this chapter apply to both FDD and TDD, but in some areas TDD receives special solutions due to the frame being divided between uplink and downlink. The resulting differences needed for a TDD implementation are covered in Chapter 15.

### 5.2 Transport Channels and their Mapping to the Physical Channels

By the nature of the design already discussed, the LTE contains only common transport channels; a dedicated transport channel (Dedicated Channel, DCH, as in WCDMA) does

LTE for UMTS: Evolution to LTE-Advanced, Second Edition. Edited by Harri Holma and Antti Toskala.  
© 2011 John Wiley & Sons, Ltd. Published 2011 by John Wiley & Sons, Ltd. ISBN: 978-0-470-66000-3

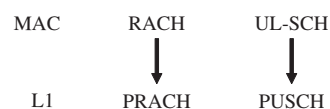
IPR2022-00457

not exist. The transport channels are the ‘interface’ between the MAC layer and the physical layer. In each transport channel, the related physical layer processing is applied to the corresponding physical channels used to carry the transport channel in question. The physical layer is required to have the ability to provide dynamic resource assignment both in terms of data-rate variance and in terms of resource division between different users. This section presents the transport channels and their mapping to the physical channels.

- The Broadcast Channel (BCH) is a downlink broadcast channel that is used to broadcast the necessary system parameters to enable devices accessing the system. Such parameters include, for example, the cell’s bandwidth, the number of transmit antenna ports, the System Frame Number and PHICH-related configuration.
- The Downlink Shared Channel (DL-SCH) carries the user data for point-to-point connections in the downlink direction. All the information (either user data or higher layer control information) intended for only one user or UE is transmitted on the DL-SCH, assuming the UE is already in the RRC\_CONNECTED state. However, as in LTE, the role of BCH is mainly to inform the device of the scheduling of the system information. Control information intended for multiple devices is also carried on DL-SCH. In case data on DL-SCH are only intended for a single UE, then dynamic link adaptation and physical layer retransmissions can be used.
- The Paging Channel (PCH) is used to carry paging information for the device in the downlink direction in order to move the device from the RRC\_IDLE state to the RRC\_CONNECTED state.
- The Multicast Channel (MCH) is used to transfer multicast service content to the UEs in the downlink direction. 3GPP decided to provide full support in Release 9 (for shared carrier case).
- The Uplink Shared Channel (UL-SCH) carries the user data as well as device-originated control information in the uplink direction in the RRC\_CONNECTED state. As with the DL-SCH, dynamic link adaptation and retransmissions are available.
- The Random Access Channel (RACH) is used in the uplink to respond to the paging message or to initiate the move from the RRC\_CONNECTED state due to UE data transmission needs. There is no higher layer data or user data transmitted on RACH (as can be done with WCDMA) but it is used to enable UL-SCH transmission where, for example, actual connection set up with authentication and so forth will take place.

In the uplink direction the UL-SCH is carried by the Physical Uplink Shared Channel (PUSCH). The RACH is carried by the Physical Random Access Channel (PRACH). Additional physical channels exist but these are used only for physical layer control information transfer as covered in section 5.6 on control information. Transport channel mapping is illustrated in Figure 5.1.

In the downlink direction, the PCH is mapped to the Physical Downlink Shared Channel (PDSCH). The BCH is mapped to Physical Broadcast Channel (PBCH) but, as is shown



**Figure 5.1** Mapping of the uplink transport channels to the physical channels

IPR2022-00457

# Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

## Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

## Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

## Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

## API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

## LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

## FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

## E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.