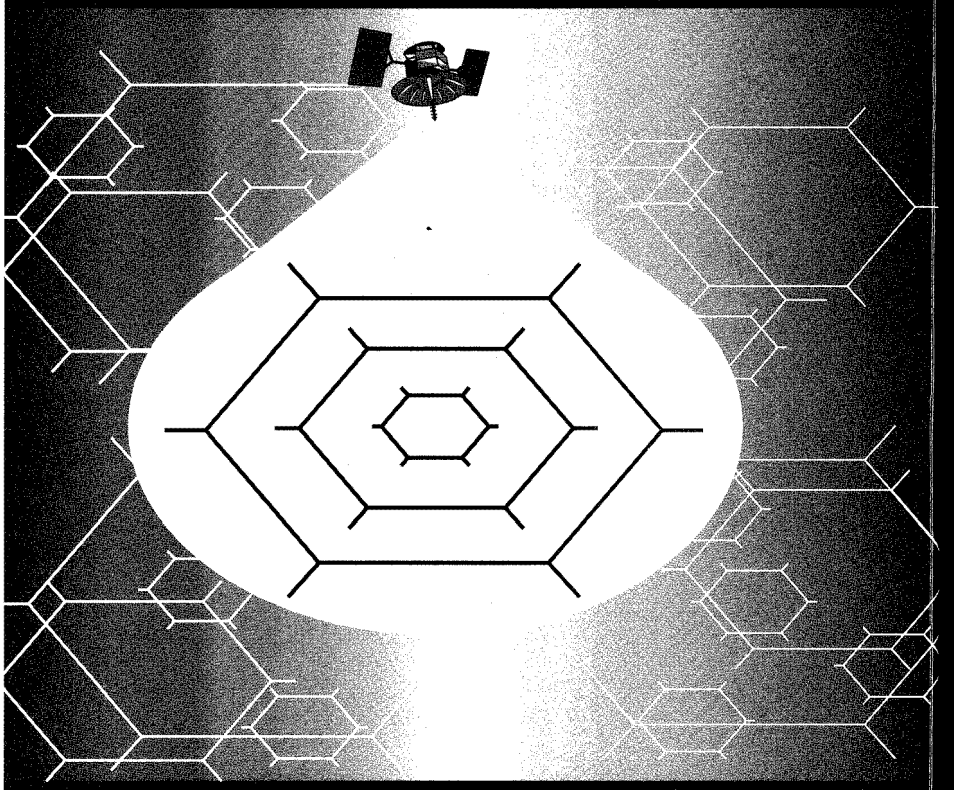
EXHIBIT H

MOBILE COMMUNICATIONS SERIES

CDMA FOR WIRELESS PERSONAL COMMUNICATIONS



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Artech House Publishers BOSTON • LONDON

CDMA for Wireless Personal Communications

Library of Congress Cataloging-in-Publication Data
Prasad, Ramjee.
CDMA for wireless personal communications / Ramjee Prasad.
p. cm.
Includes bibliographical references and index.
ISBN 0-89006-571-3 (alk. paper)
1. Code division multiple access. 2. Wireless personal communications.
I. Title.
TK5103.45.P73 1996
621.3845—dc20 95-53774
CIP

British Library Cataloguing in Publication Data
Prasad, Ramjee
CDMA for wireless personal communications
1. Code division multiple access 2. Wireless communication systems
I. Title
621.3'82

ISBN 0-89006-571-3

International Standard Book Number: 0-89006-571-3
Library of Congress Catalog Card Number: 96-53774

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2.3 CONTENTIONLESS (SCHEDULING) MULTIPLE ACCESS PROTOCOLS

The contentionless MA protocols avoid the situation in which multiple users try to access the same channel at the same time by scheduling the transmissions of all users. The users transmit in an orderly scheduled manner so every transmission will be a successful one. The scheduling can take two forms:

1. Fixed assignment scheduling. With these types of protocols, the available channel capacity is divided among the users such that each user is allocated a fixed part of the capacity, independent of its activity. The division can be done in time or frequency. The time division results in the TDMA protocol, where transmission time is divided into frames and each user is assigned a fixed part of each frame, not overlapping with parts assigned to other users. The frequency division results in the FDMA protocol where the channel bandwidth is divided into nonoverlapping frequency bands and each user is assigned a fixed band.
2. Demand assignment scheduling. A user is only allowed to transmit if it is active (if it has something to transmit). Thus the *active* (or ready) users transmit in an orderly scheduled manner. Within the demand assignment scheduling we can distinguish between centralized control and distributed control. With centralized control a single entity schedules the transmissions. An example of such a protocol is the roll-call polling protocol. With distributed control all users are involved in the scheduling process and such a protocol is the token-passing protocol.

2.3.1 Fixed Assignment

With the fixed assignment multiple access protocols, the channel capacity is divided among the users in a static fashion; each user is allocated part of the channel capacity whether it has something to transmit or not. The allocation can take part in time or frequency, which results in the TDMA protocol and the FDMA protocol, respectively.

Time Division Multiple Access

In the *basic* TDMA protocol, the (transmission) time axis is divided into frames of equal duration, and each frame is divided into the same number of time slots. All time slots have equal duration. Each slot position within a frame is allocated to a different user and this allocation stays the same over the sequence of frames. This means that a particular user may transmit during one particular slot in every frame. During this slot it has the whole channel bandwidth at its disposal. Figure 2.2 shows the allocation in a basic TDMA frame with four time slots per frame. The shaded areas in this figure depict the guard times in each time slot in which transmission by a user is prohibited. These guard

times are necessary to prevent transmissions of different (spatially distributed) users from overlapping due to transmission delay differences.

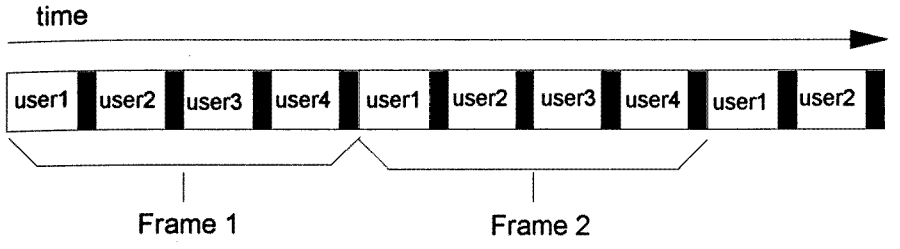

Figure 2.2 Frame and slot structure with basic TDMA.

With the basic TDMA protocol every user is allocated the same capacity, namely, one slot per frame. Thus the amount of traffic that can be transmitted within one slot must be enough to accommodate the user which generates most traffic. But this means that users generating much less traffic waste a lot of capacity. For this reason more generalized TDMA protocols have been developed that allow users to be allocated more than one slot per frame and also allow for the slots within one frame to be of different duration. However capacity is still wasted if a user has nothing to transmit in its allocated time slot.

Despite this capacity-wasting property, TDMA has been and still is used extensively because of its relative simplicity. The only real problem encountered with TDMA is that of achieving the necessary synchronization of all users so that each user knows when and for how long it can transmit.

Frequency Division Multiple Access

With FDMA, the bandwidth of the communication channel is divided into a number of frequency bands with guard bands between them to achieve frequency separation of adjacent bands. Each user is allocated a particular frequency band for its own private use. Thus with FDMA, a user can use part of the transmission channel all the time.

FDMA has the same capacity-wasting properties as TDMA, because if a user has nothing to transmit, its frequency band cannot be used by other users. It also gives a slightly inferior performance with respect to packet delay. FDMA does, however, have the advantage of being even simpler than TDMA because no synchronization of the users is necessary.