COMPUTER NETWORKS

Chapter 2. The Physical Layer

Part 4

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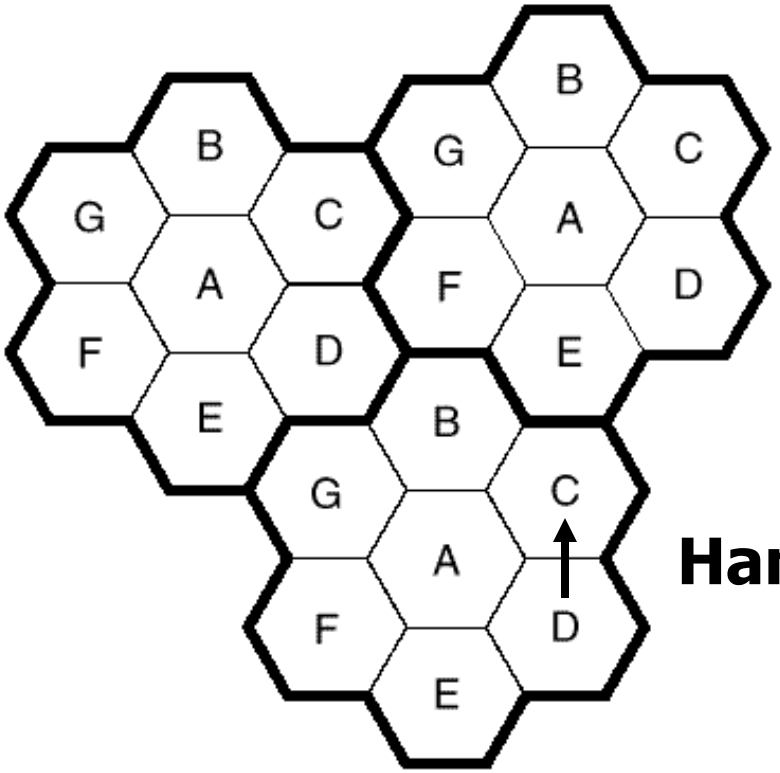
The Mobile Telephone System

Despite an initial lead by US, mobile phone ownership and usage in Europe is now far greater than in US.

Three reasons:
1.Single GSM system
2.Differentiated and recognizable mobile phone number
3.Prepaid cards

First Generation Mobile Phones: Analog Voice

AMPS (Advanced Mobile Phone System)

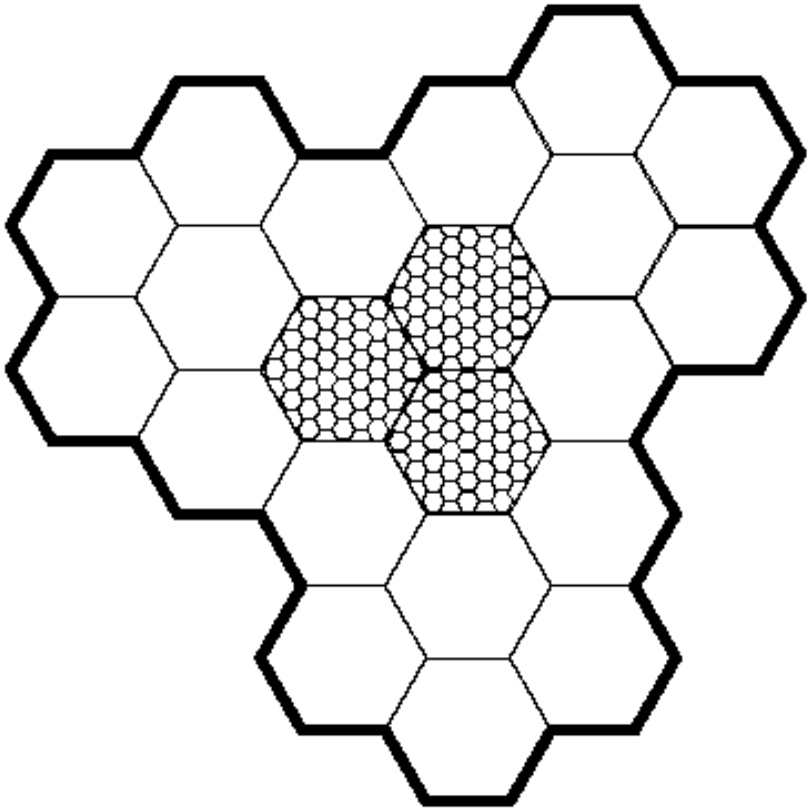


Cell structure and frequency reuse

Handoff

First Generation Mobile Phones: Analog Voice

AMPS (Advanced Mobile Phone System)



Microcells to increase frequency reuse and cheaper handset

First Generation Mobile Phones: Analog Voice

AMPS (Advanced Mobile Phone System)

The AMPS system uses **832 full-duplex channels**, each consisting of a pair of simplex channels. There are 832 simplex transmission channels from **824 to 849 MHz** and 832 simplex receive channels from **869 to 894 MHz**. Each of these simplex channels is 30 kHz wide. Thus AMPS uses FDM to separate the channels.

First Generation Mobile Phones: Analog Voice

AMPS (Advanced Mobile Phone System)

The 832 channels are divided into four categories:

- Control (base to mobile) to manage the system
- Paging (base to mobile) to alert users to calls for them
- Access (bidirectional) for call setup and channel assignment
- Data (bidirectional) for voice, fax, or data

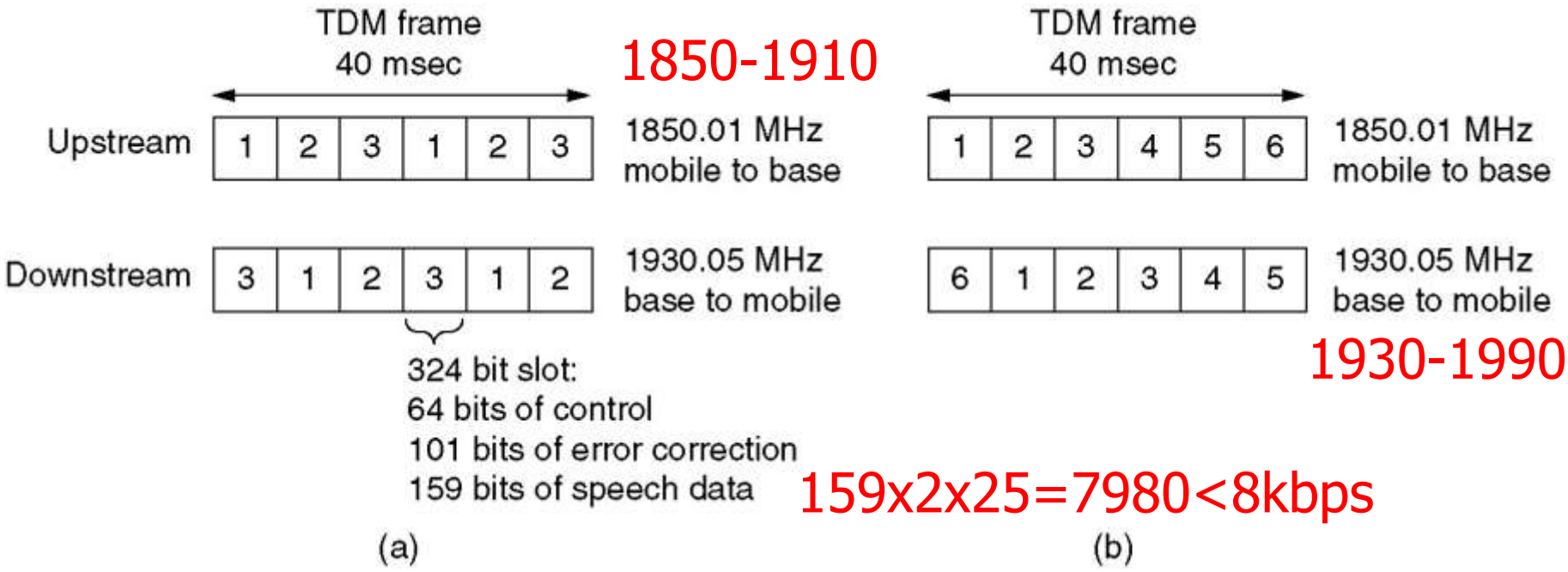
First Generation Mobile Phones: Analog Voice

AMPS (Advanced Mobile Phone System)

Soft handoff: connect to two base stations simultaneously (need phone to tune to two frequencies)

Hard handoff: old base station drops before the new one acquires it.(1G 2G)

Second Generation Mobile Phones: Digital Voice



(a) D-AMPS channel with three users.

(b) D-AMPS channel with six users.

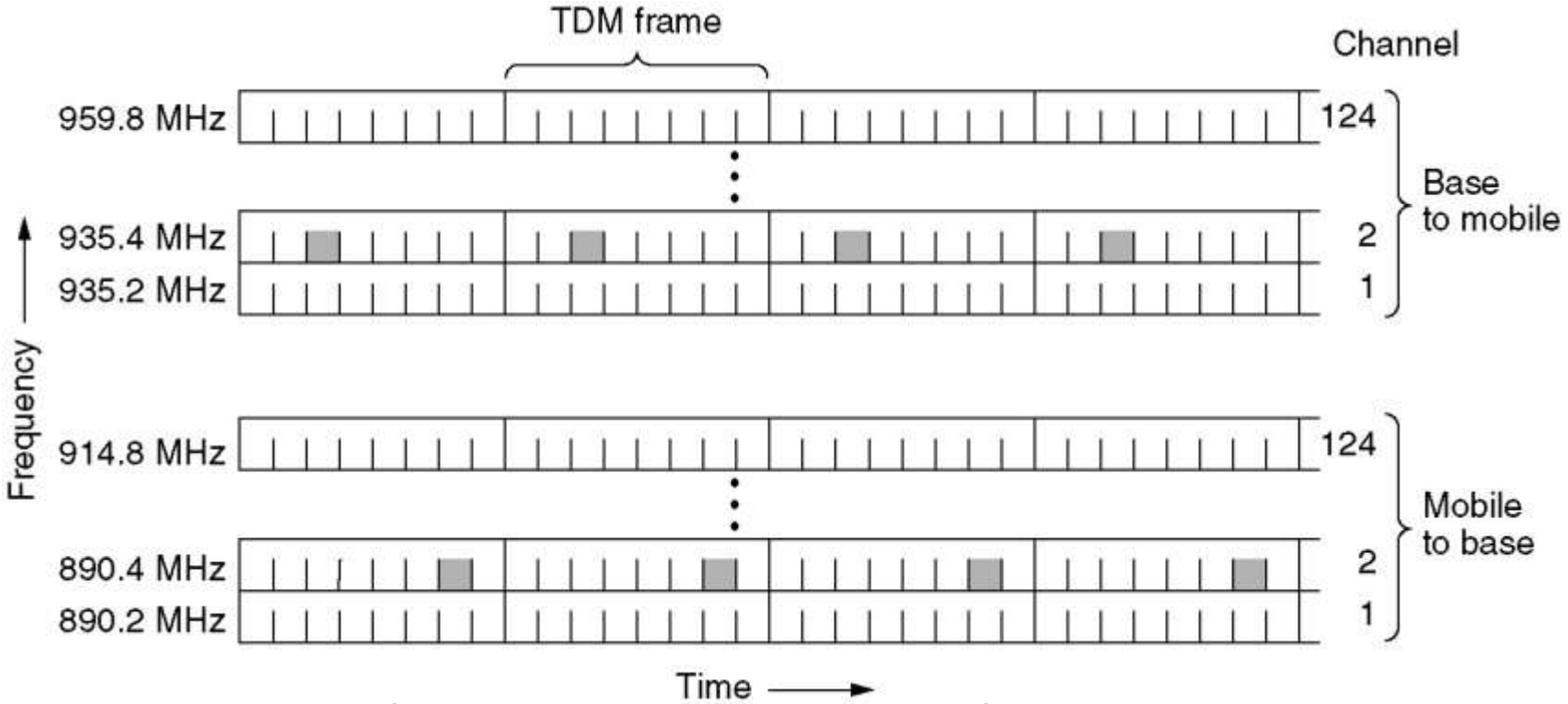
Second Generation Mobile Phones: Digital Voice

MAHO (Mobile Assisted HandOff)

1/3 of the time a mobile is neither sending nor receiving. It uses these idle times to measure the line quality. When it discovers that the signal is waning, it complains to the MTSO (Mobile Telephone Switching Office, or MSC, Mobile Switching Center), which can then break the connection.

Second Generation Mobile Phones: Digital Voice

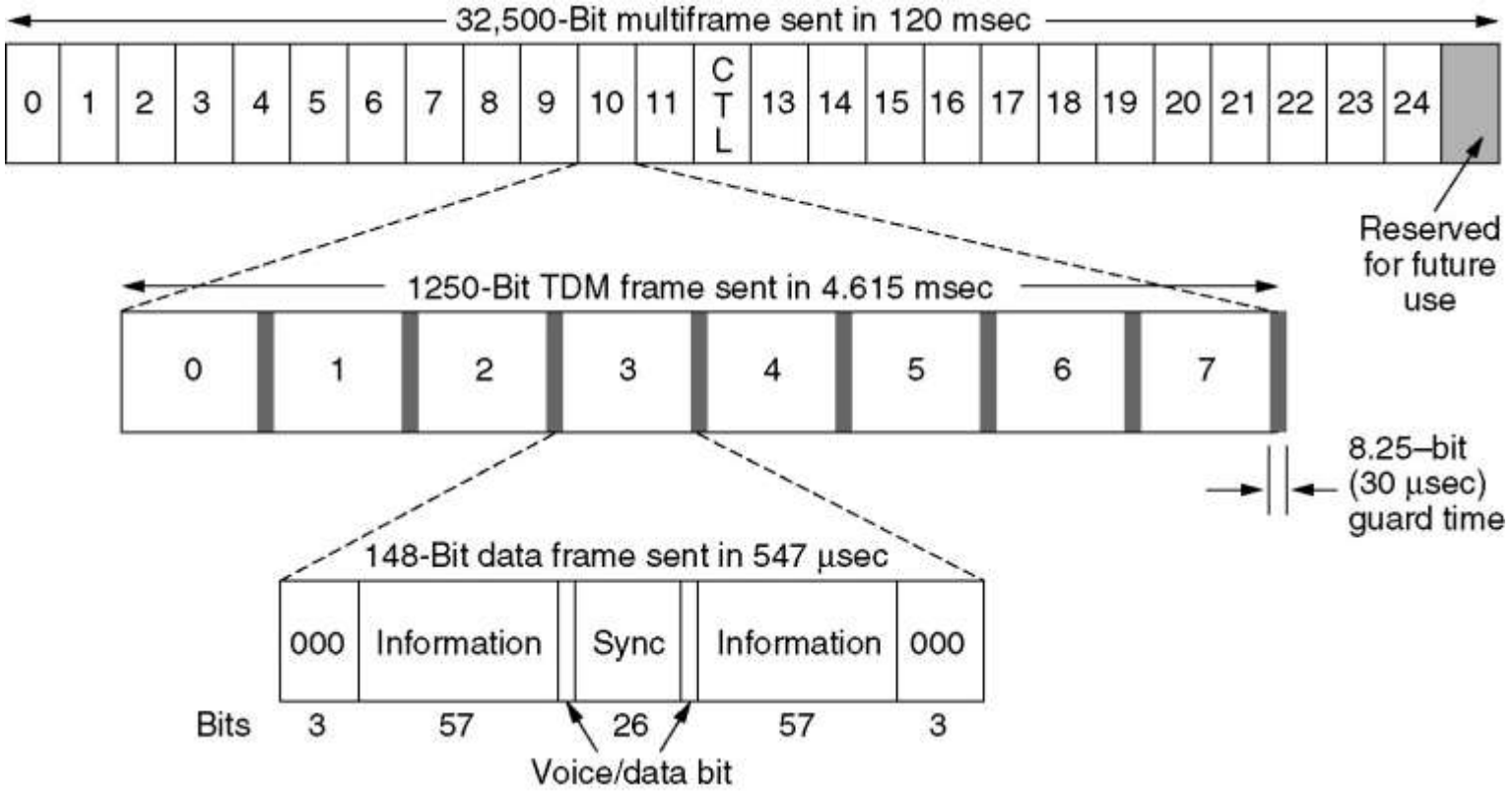
GSM: The Global System for Mobile Communications



GSM uses 124 frequency channels, each of which uses an eight-slot TDM system

Second Generation Mobile Phones: Digital Voice

GSM: The Global System for Mobile Communications



Second Generation Mobile Phones: Digital Voice

GSM: The Global System for Mobile Communications

Broadcast control channel: base station id and channel status
Dedicated control channel: location update, registration, call setup
Common control channel
- Paging channel
- Random access channel
- Access grant channel

Second Generation Mobile Phones: Digital Voice

CDMA: Code Division Multiple Access

In an airport lounge with many pairs of people conversing:
TDMA: take turns speaking
FDMA: people in widely separated clumps, each clump holding its own conversation
CDMA: all talking at once, but with each pair in a different language

The key to the CDMA is to be able to extract the desired signal while rejecting everything else as random noise.

Second Generation Mobile Phones: Digital Voice

CDMA: Code Division Multiple Access

In CDMA, each bit time is subdivided into m short intervals called **chips**. Typically, there are 64 or 128 chips per bit.

Each station is assigned a unique m-bit code called a chip sequence. To transmit a **1 bit, it sends its chip sequence**. To transmit a **0 bit, it sends the 1's complement** of its chip sequence.

Second Generation Mobile Phones: Digital Voice

CDMA: Code Division Multiple Access

A: 0 0 0 1 1 0 1 1
B: 0 0 1 0 1 1 1 0
C: 0 1 0 1 1 1 0 0
D: 0 1 0 0 0 0 1 0

(a)

A: (–1 –1 –1 +1 +1 –1 +1 +1)
B: (–1 –1 +1 –1 +1 +1 +1 –1)
C: (–1 +1 –1 +1 +1 +1 –1 –1)
D: (–1 +1 –1 –1 –1 –1 +1 –1)

(b)

Six examples:

– – 1 –	**C**	$S_1 = (-1 +1 -1 +1 +1 +1 -1 -1)$
– 1 1 –	**B** + $\overline{\mathbf{C}}$	$S_2 = (-2 \ 0 \ 0 \ 0 +2 +2 \ 0 -2)$
1 0 – –	**A** + $\overline{\mathbf{B}}$	$S_3 = (\ 0 \ 0 -2 +2 \ 0 -2 \ 0 +2)$
1 0 1 –	**A** + **B** + **C**	$S_4 = (-1 +1 -3 +3 +1 -1 -1 +1)$
1 1 1 1	**A** + **B** + **C** + **D**	$S_5 = (-4 \ 0 -2 \ 0 +2 \ 0 +2 -2)$
1 1 0 1	**A** + **B** + $\overline{\mathbf{C}}$ + **D**	$S_6 = (-2 -2 \ 0 -2 \ 0 -2 +4 \ 0)$

(c)

$S_1 \bullet C = (1 +1 +1 +1 +1 +1 +1 +1)/8 = 1$
$S_2 \bullet C = (2 +0 +0 +0 +2 +2 +0 +2)/8 = 1$
$S_3 \bullet C = (0 +0 +2 +2 +0 -2 +0 -2)/8 = 0$
$S_4 \bullet C = (1 +1 +3 +3 +1 -1 +1 -1)/8 = 1$
$S_5 \bullet C = (4 +0 +2 +0 +2 +0 -2 +2)/8 = 1$
$S_6 \bullet C = (2 -2 +0 -2 +0 -2 -4 +0)/8 = -1$

(d)

(a) Binary chip sequences for four stations
(b) Bipolar chip sequences
(c) Six examples of transmissions
(d) Recovery of station C's signal

Third Generation Mobile Phones: Digital Voice and Data

Basic services an IMT-2000 network should provide

- High-quality voice transmission
- Messaging (replace e-mail, fax, SMS, chat, etc.)
- Multimedia (music, videos, films, TV, etc.)
- Internet access (web surfing, w/multimedia.)

Third Generation Mobile Phones: Digital Voice and Data

Europe: W-CDMA (Wideband CDMA), called UMTS (Universal Mobile Telecommunication System)

US: CDMA2000

In between 2G and 3G:
EDGE (Enhanced Data rate for GSM Evolution): more bits per baud

GPRS (Generalized Packet Radio Service): some GSM channels for data

Third Generation Mobile Phones: Digital Voice and Data

4G: high bandwidth, ubiquity, seamless integration with IP, adaptive resource and spectrum management, software radios, high quality of service for multimedia

802.11 (Wi-Fi): WiMax