

# EEE4121F-A

# Mobile and Wireless Networks

Multiple Access and Duplex

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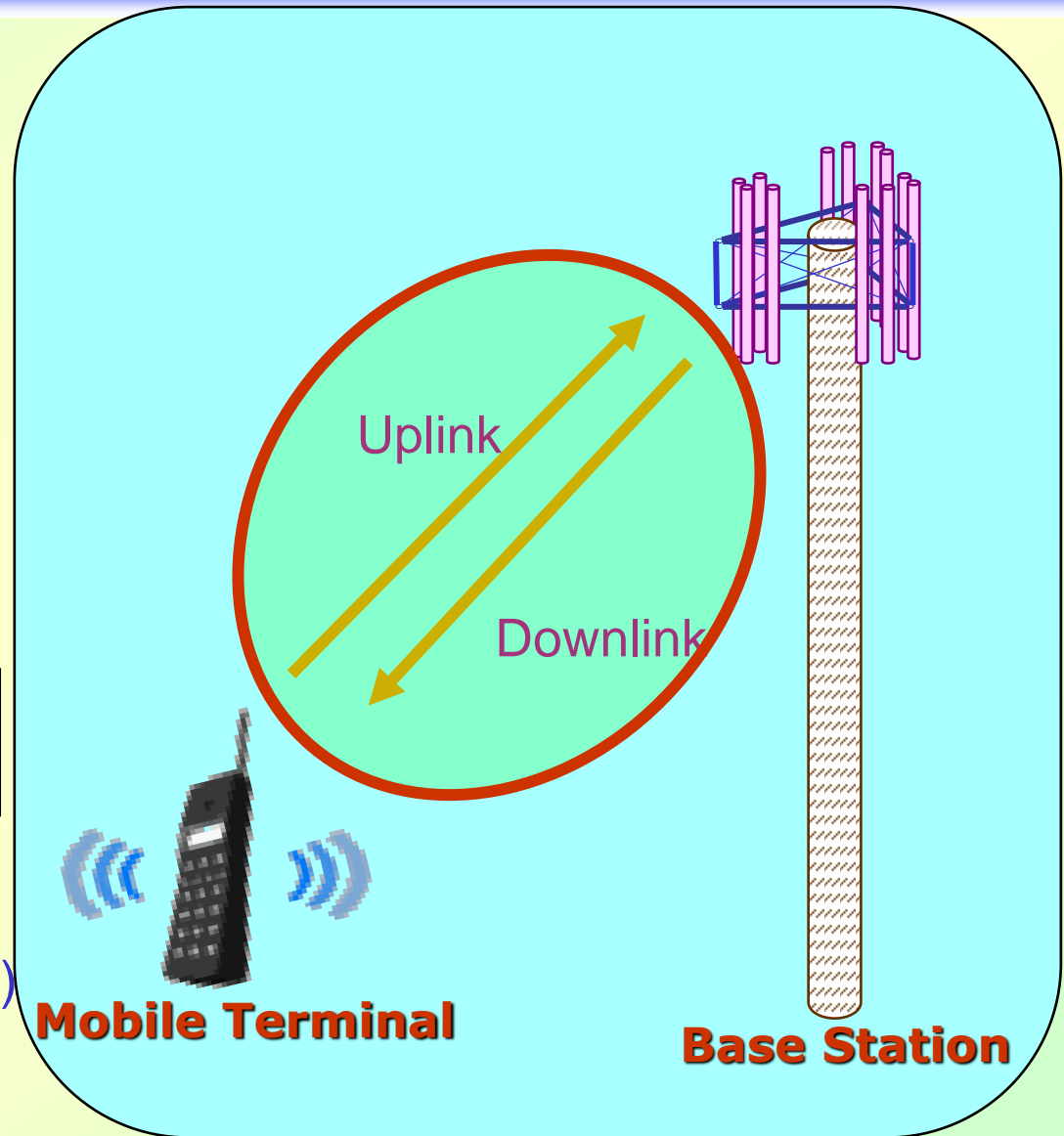
# Multiple Access and Duplex

## ◆ Multiple Access Techniques:

- FDMA
- TDMA
- CDMA
- OFDMA
- SDMA
- NOMA

## ◆ Duplex Techniques:

- Frequency division (FDD)
- Time division (TDD)
- Code division (CDD)
- Space division (SDD)
- Polarization division (PDD)
- Hybrid division (HDD)



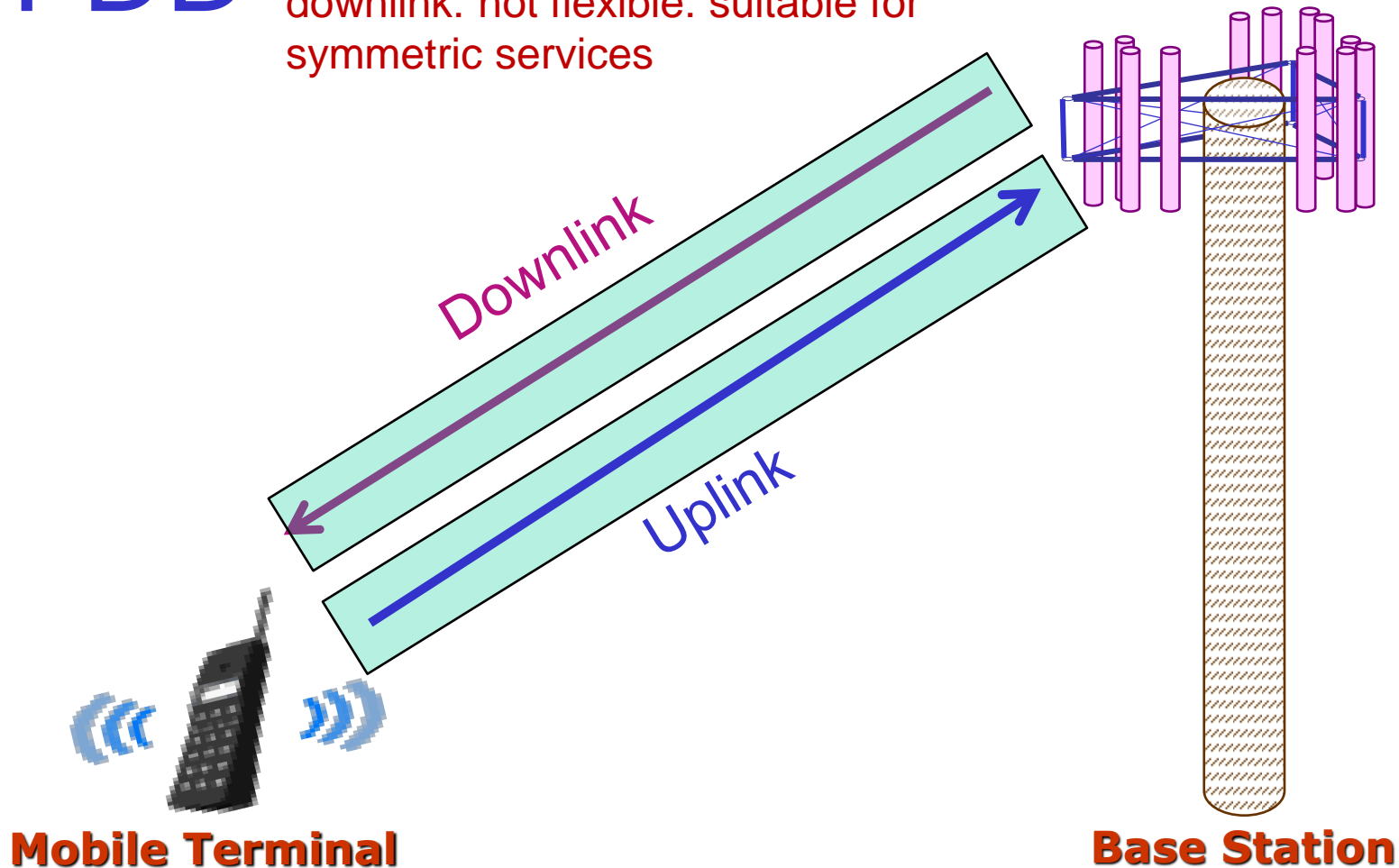
# Duplex Techniques in Wireless Networks

- ◆ Frequency division:
  - divides the channel into different frequencies
- ◆ Time division:
  - shares bandwidth channel in time
- ◆ Code division:
  - assigns a unique code to encode data
- ◆ Space division:
  - spot beam antennas are used to separate radio signals
- ◆ Polarization division:
  - orthogonal polarizations are used to separate signals
- ◆ Hybrid division:
  - Combines frequency division and time division

# Duplex Techniques in Wireless Networks

## FDD

Different frequencies in uplink and downlink: not flexible: suitable for symmetric services



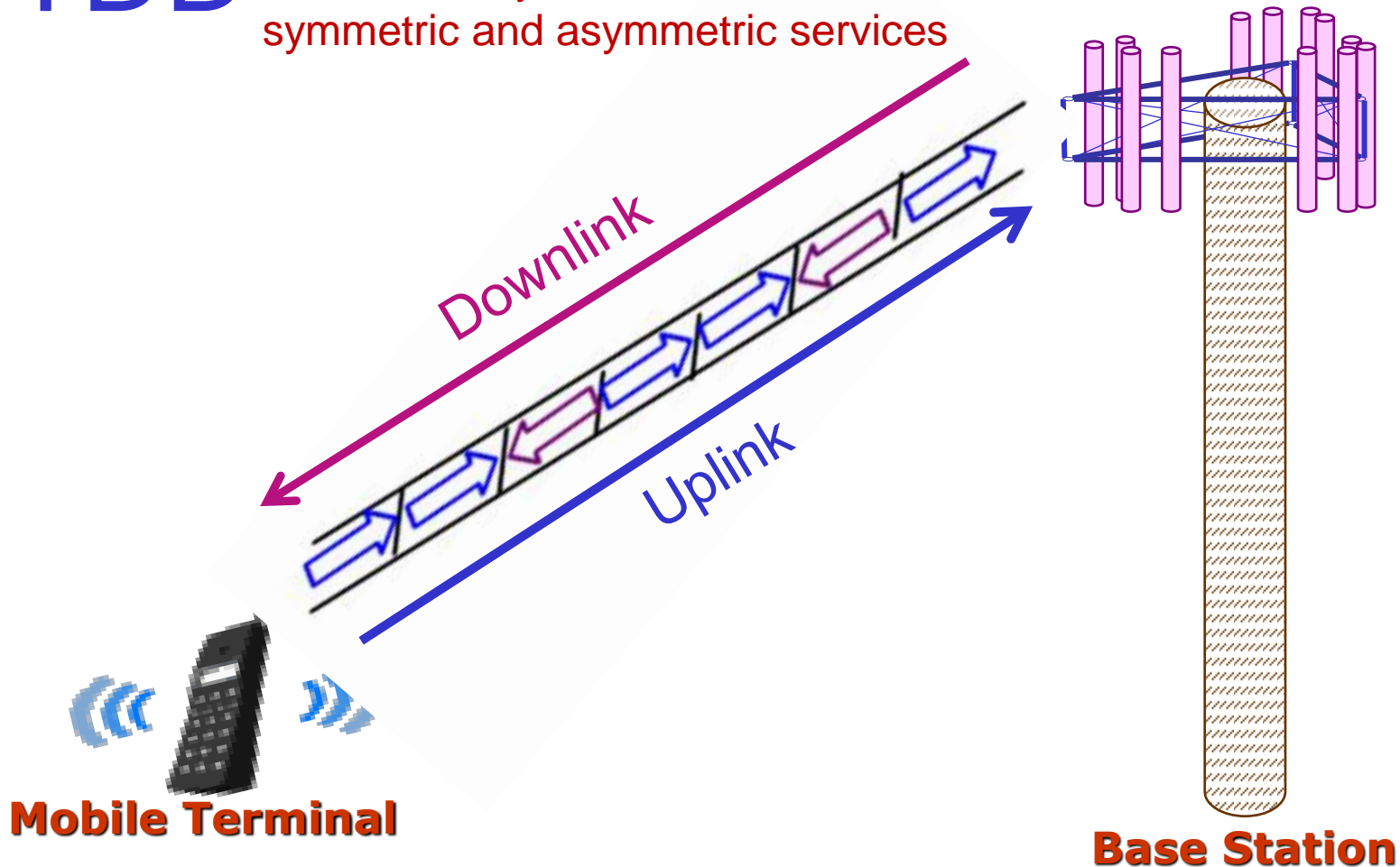
# Multiple Access and Duplex

- ◆ Frequency Division Duplex (FDD): Uplink and downlink transmissions use two separated radio frequencies in different frequency bands. A pair of frequency bands with specified separation is assigned for the system.

# Duplex Techniques in Wireless Networks

## TDD

Different time slots in uplink and downlink: very flexible, suitable for both symmetric and asymmetric services



# Multiple Access and Duplex

- ◆ Time Division Duplex (TDD): Uplink and downlink transmissions are carried over same radio frequency by using synchronized time slots that divide the physical channel into transmission and reception part. Information on uplink and downlink are transmitted using different time slots.

# Multiple Access and Duplex

- ◆ Code Division Duplex (CDD): Uplink and downlink transmissions are carried over the same radio frequency and time using different codes.



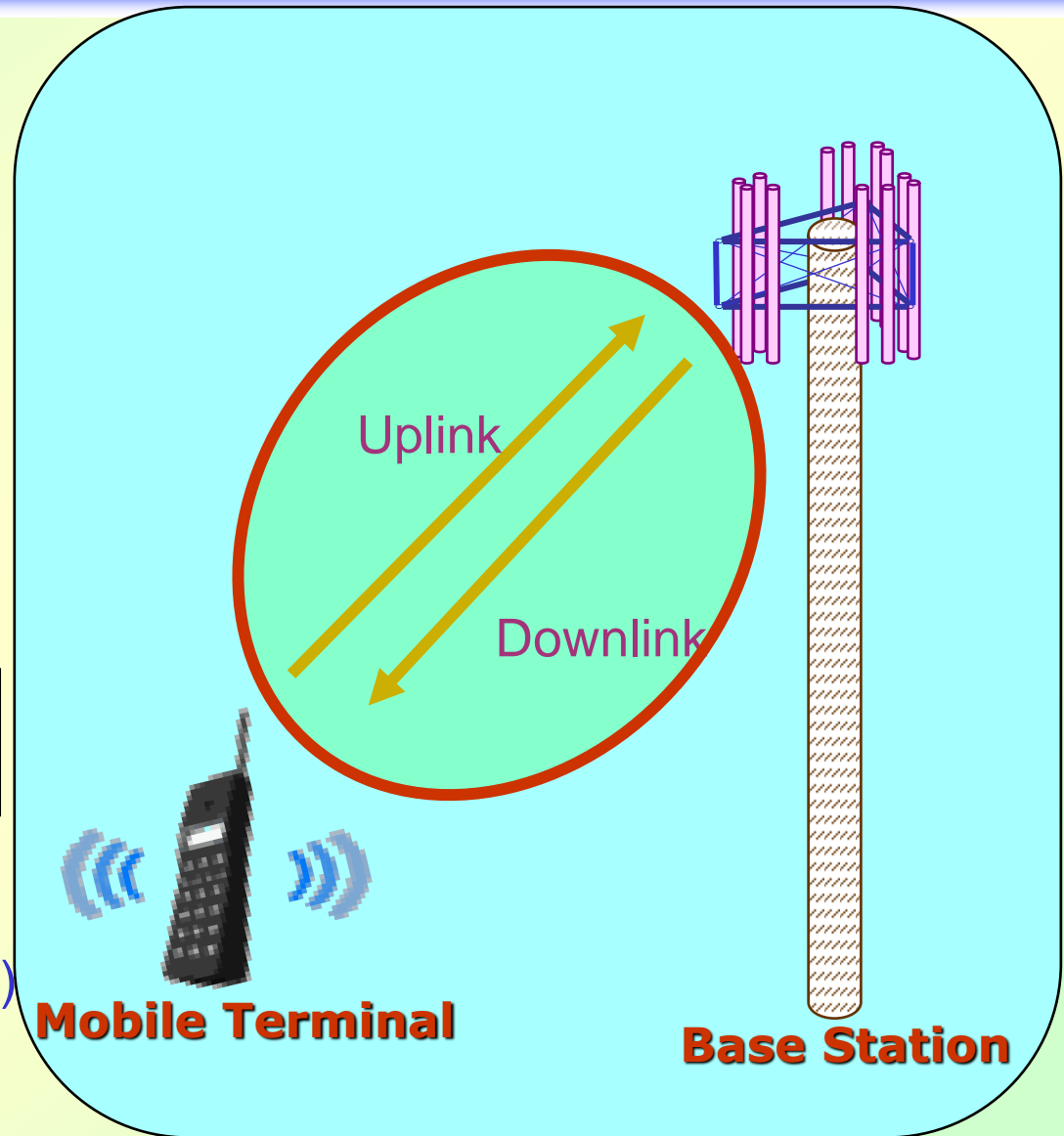
# Multiple Access and Duplex

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# Radio Access Technologies

## FDMA/FDD (as in 1st Generation Wireless)

(1) **Multiple Access** is FDMA: Frequency Division Multiple Access

- ◆ The 1st generation mobile system uses FDMA only. Example: Advanced Mobile Phone System (AMPS) in US



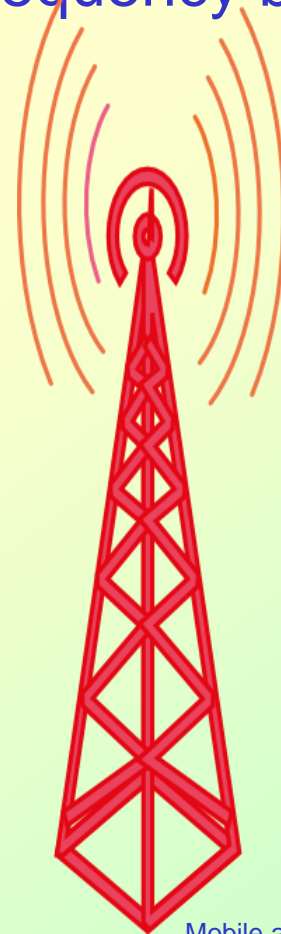
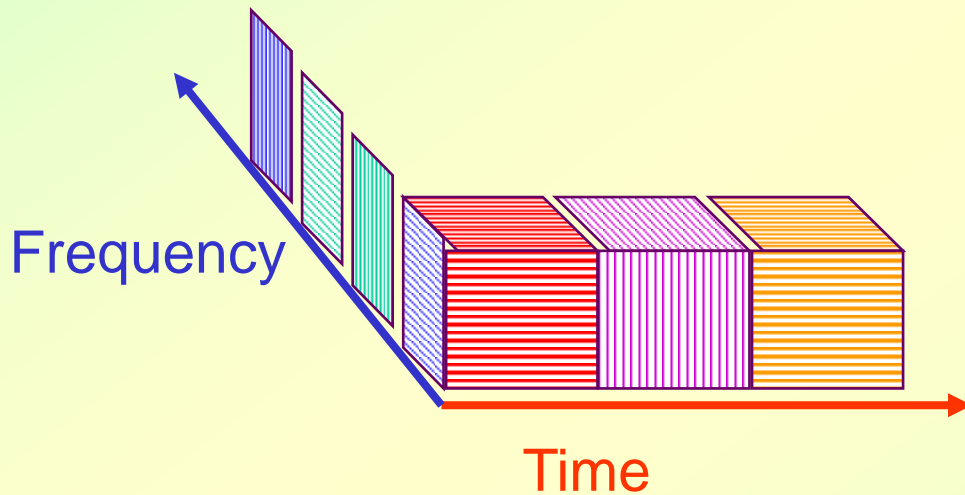
(2) **Duplex is FDD**: Frequency Division Duplex

- ◆ The FM channels are paired with an uplink and a downlink channel for each user.

# Radio Access

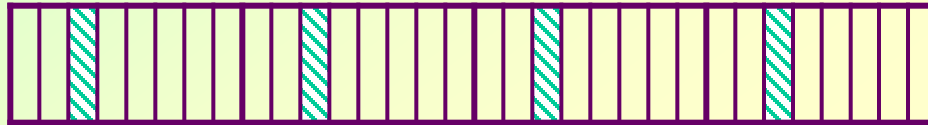
## TDMA (as in 2nd Generation wireless)

- ◆ GSM, a 2nd generation mobile system, uses 8 time slots in TDMA mode for each 200 kHz carrier. Carriers are derived from frequency division over the licensed frequency band (FDMA!)



# TDMA – Detailed Structure

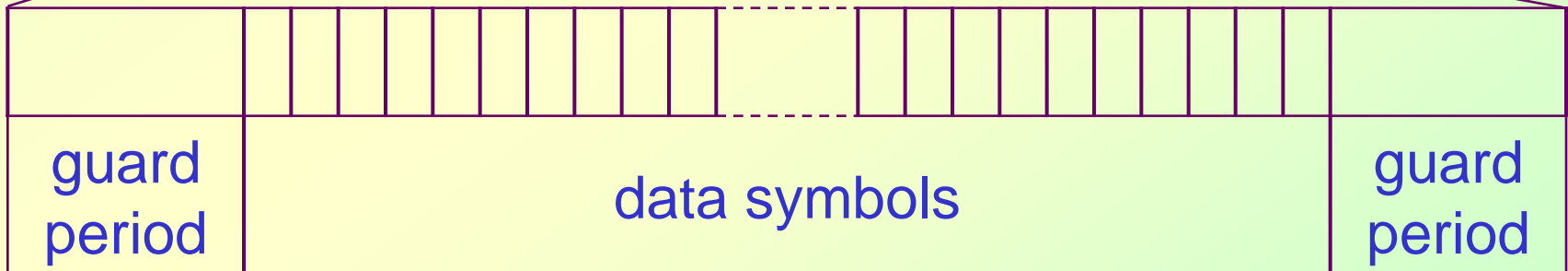
data stream contains frames



frame contains timeslots  
each user is allocated to a timeslot



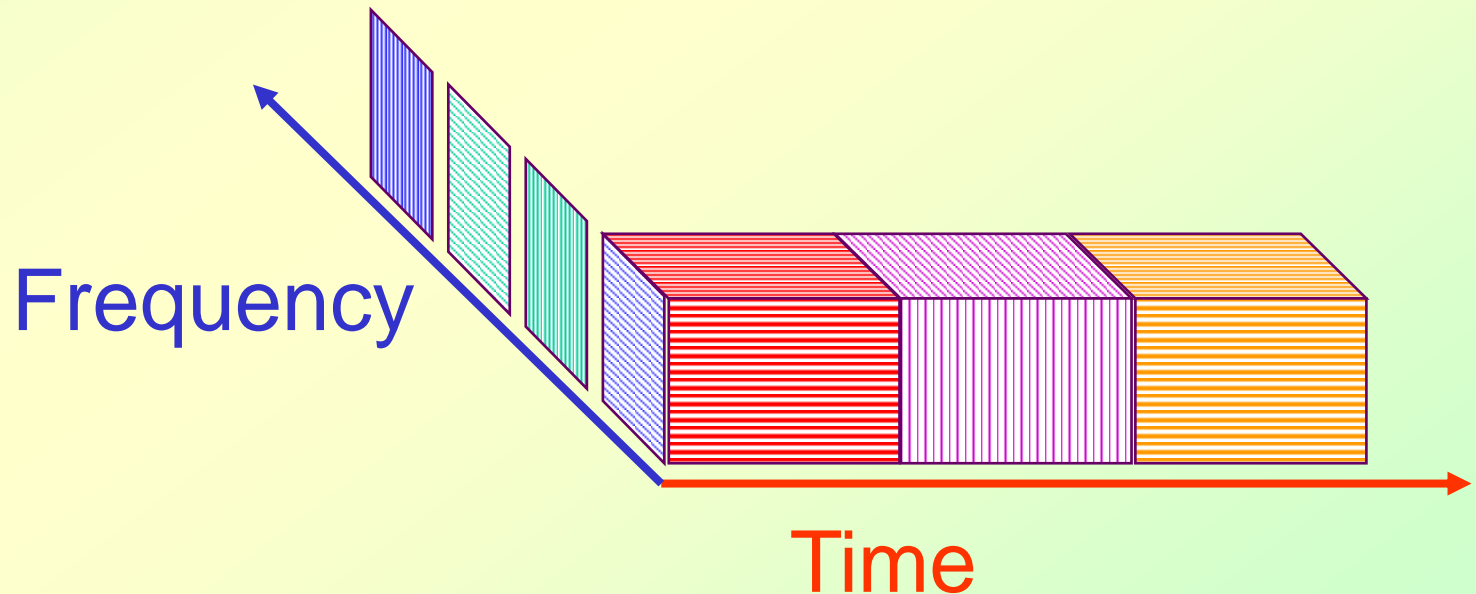
timeslot contains data and optional guard periods



# Radio Access

## TDMA (as in 2nd Generation wireless)

- ◆ Capacity in GSM is doubled by using alternate time slots to support 16 channels
- ◆ A full-rate call uses one time slot in every frame, while a half-rate call uses one time slot in every two frames



# Radio Access

## TDMA (as in 2nd Generation wireless)

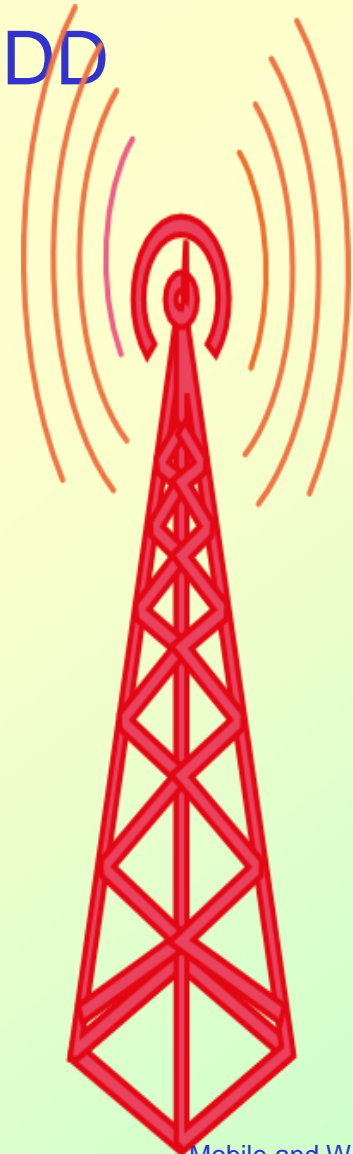
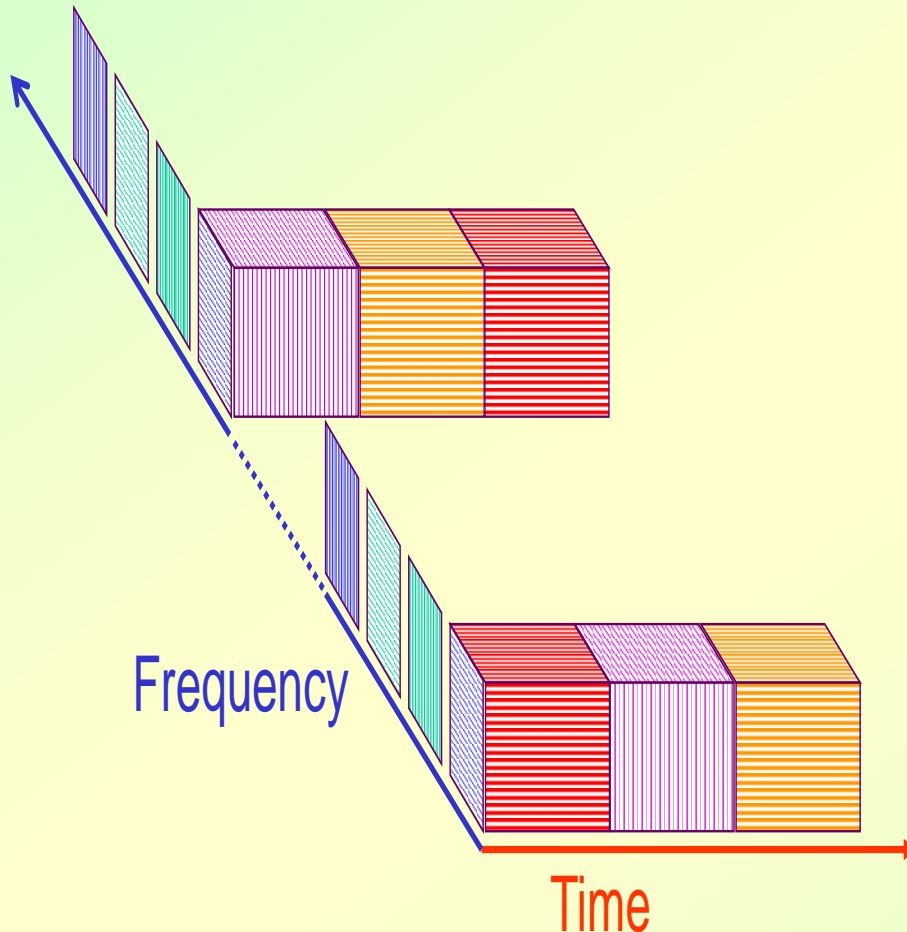
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- ◆ IS-136 TDMA or DAMP (Digital Advanced Mobile Phone (DAMP) is the American TDMA system with 3 time slots over a 30kHz carrier
- ◆ TDMA6 provides 6 channels by alternating the 3 time slots

# Radio Access

## TDMA/FDD (as in 2nd Generation wireless)

- ◆ GSM and IS-136 TDMA are TDMA/FDD

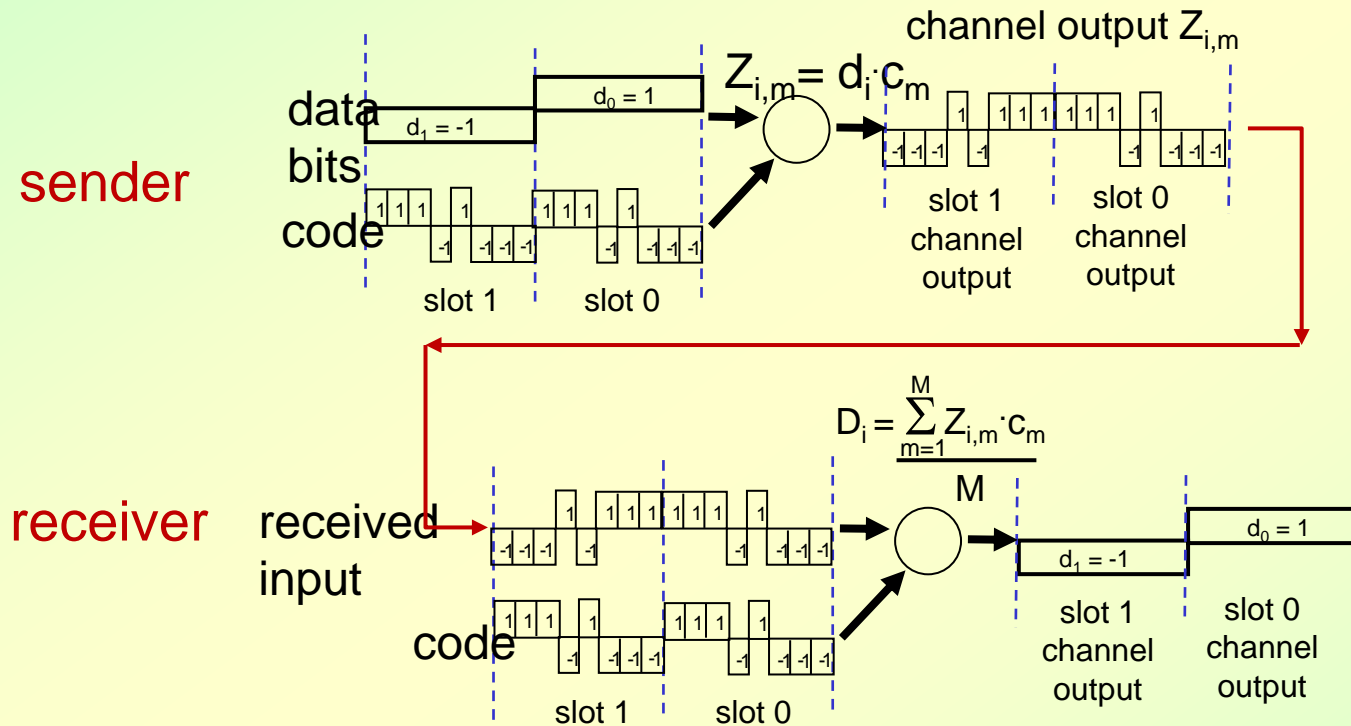


# Code Division Multiple Access (CDMA)

- ❑ unique “code” assigned to each user; i.e., code set partitioning
- ❑ all users share same frequency, but each user has own “chipping” sequence (i.e., code) to encode data
- ❑ allows multiple users to “coexist” and transmit simultaneously with minimal interference (if codes are “orthogonal”)
- ❑ encoding: inner product: (original data)  $\times$  (chipping sequence)
- ❑ decoding: summed inner-product: (encoded data)  $\times$  (chipping sequence)



# CDMA encode/decode

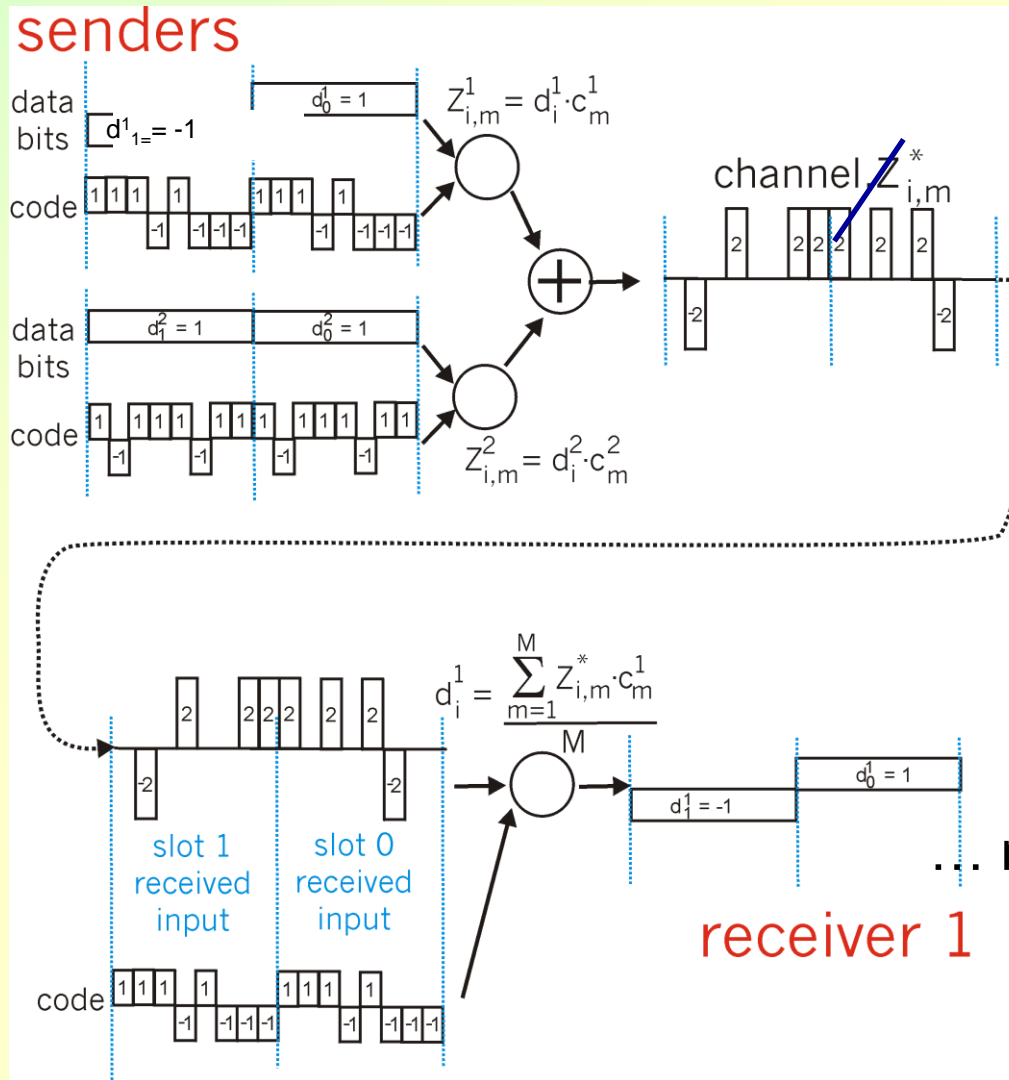


... but this isn't really useful yet!

# CDMA: two-sender interference

Sender 1

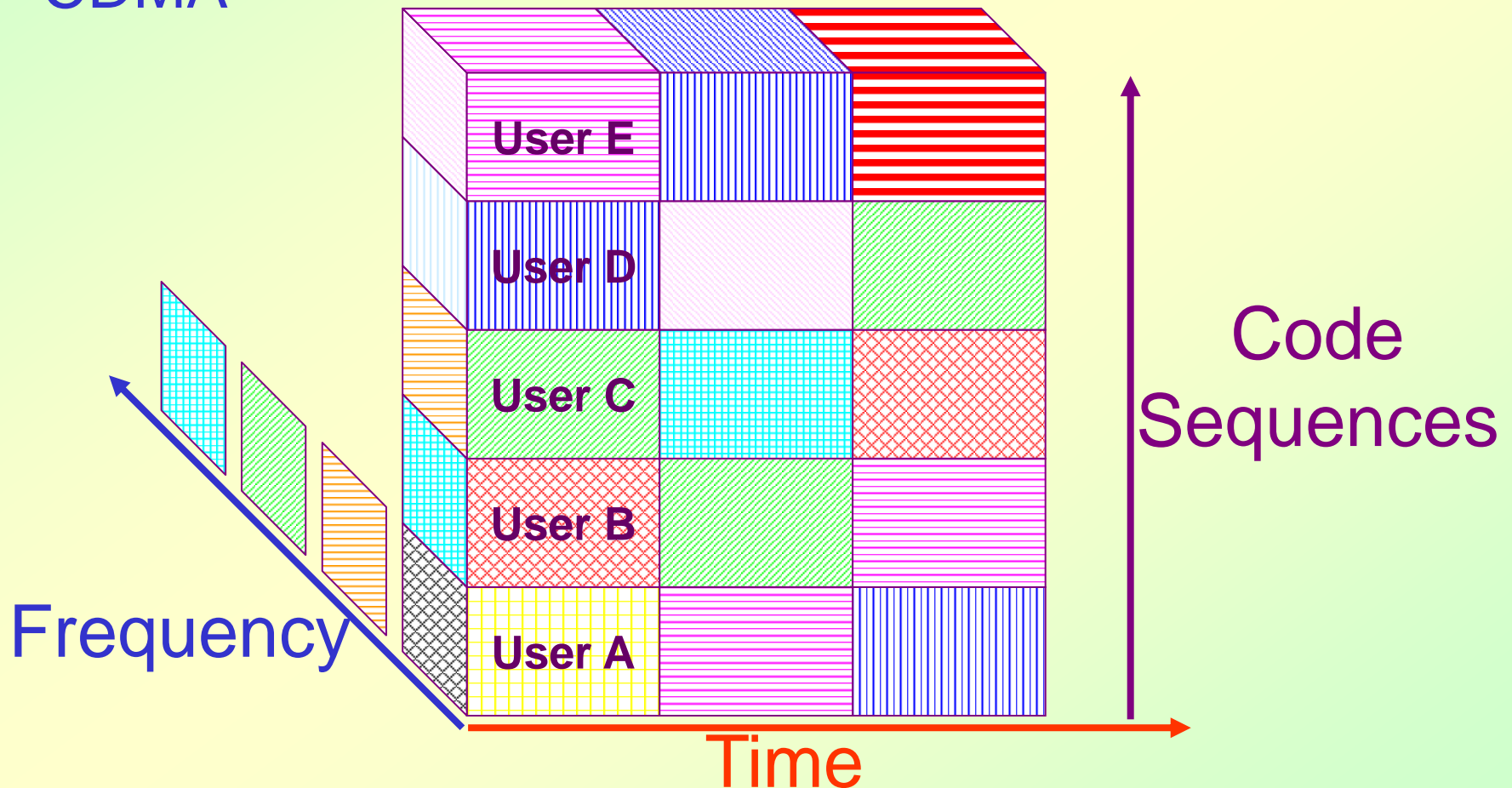
Sender 2



# Radio Access

## CDMA (as in 2nd Generation wireless)

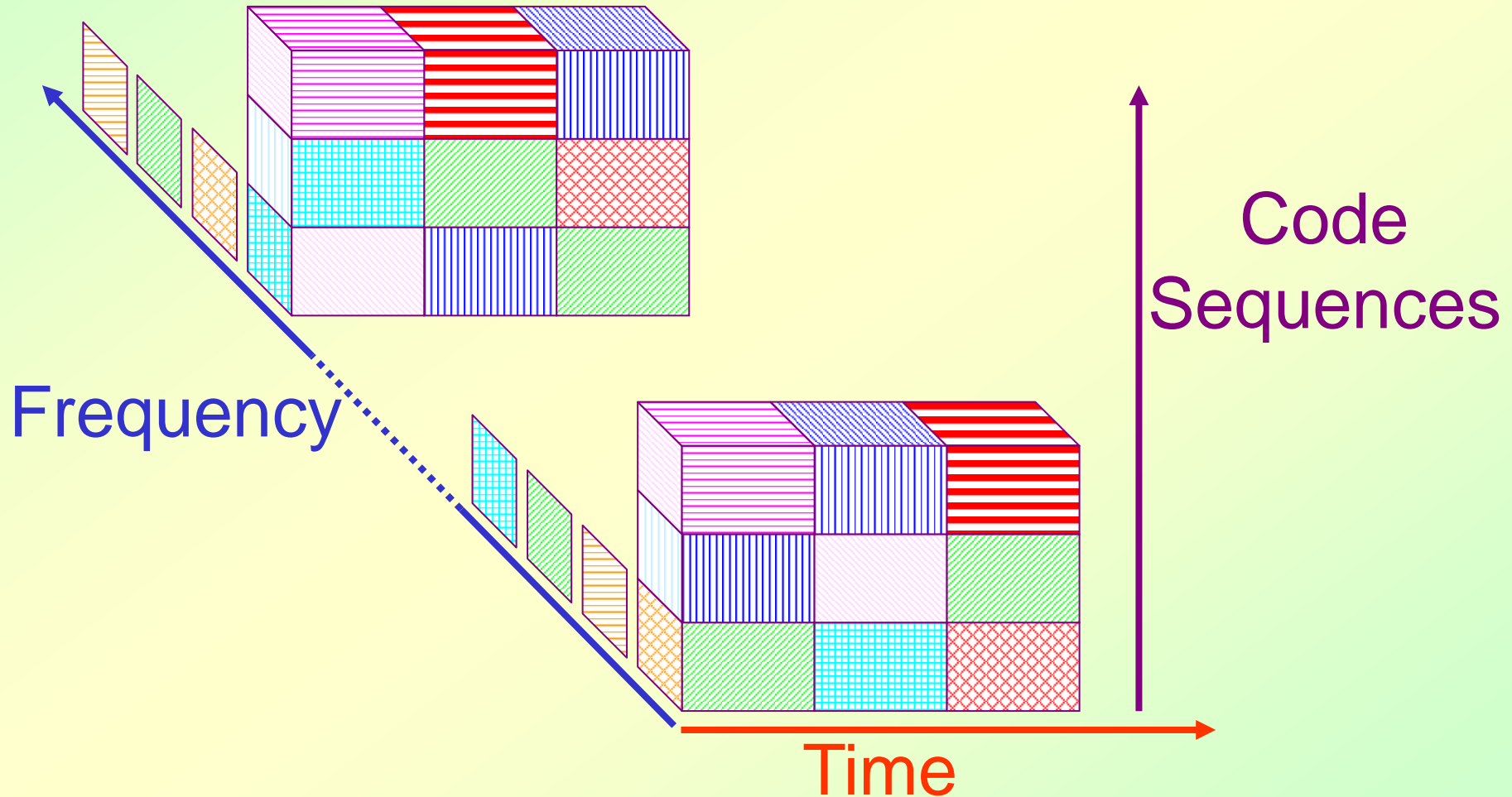
- ◆ IS-95, a 2nd generation mobile system, uses CDMA



# Radio Access

## CDMA/FDD (as in 2nd Generation wireless)

### ◆ IS-95 is CDMA/FDD



# Radio Access 2nd Generation

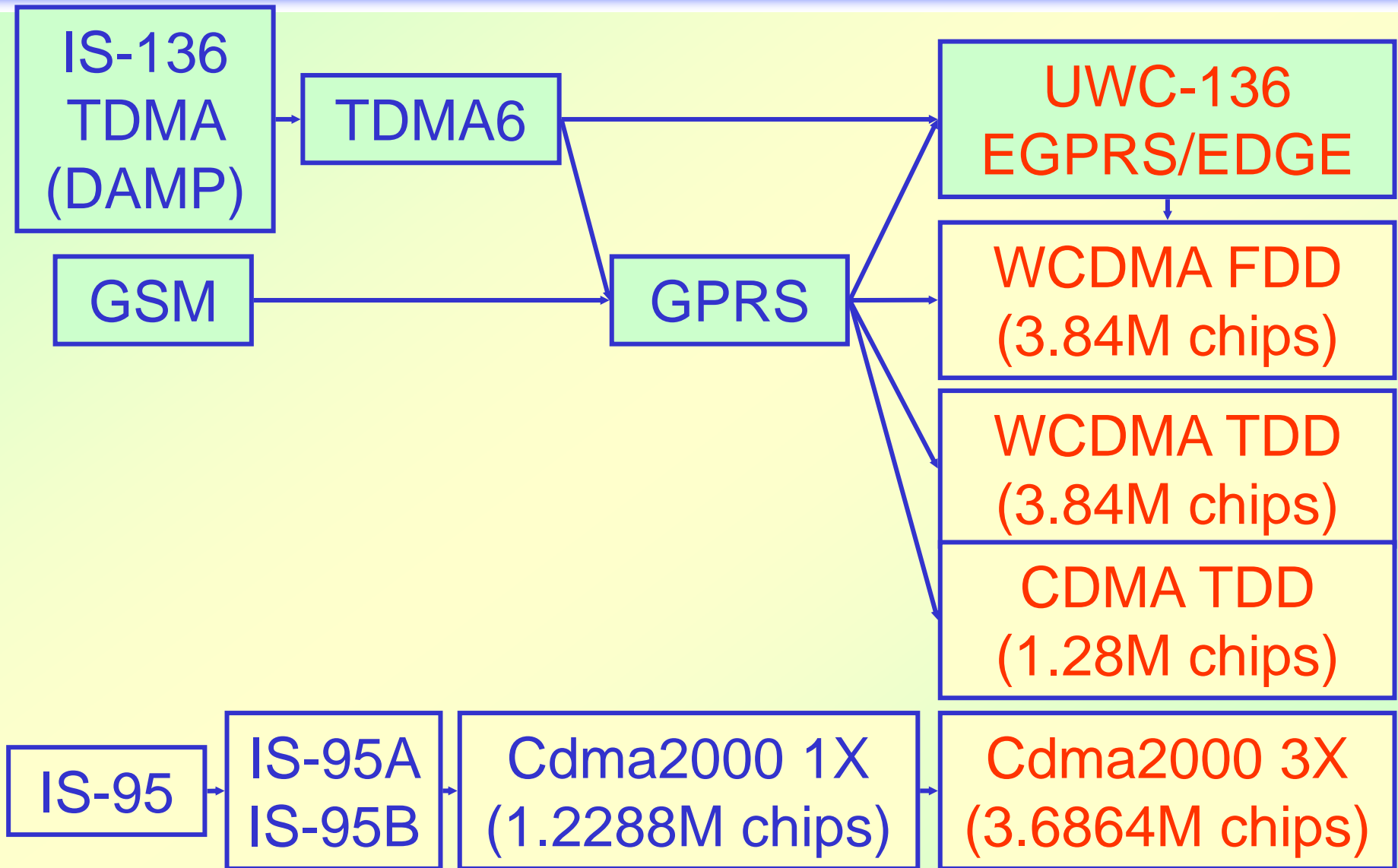
- ◆ Going from analog to digital and to CDMA makes more efficient use of the scarce radio resources (and expensive frequency spectrum license), and hence helps to lower the price.

# Radio Access

## 2G improvement is not in voice quality

- ◆ Using digital system enables signal compression before transmitting over the air. Yet, the compression algorithm and format are different from that of the wire-line. Hence calls between cellular network and PSTN networks are compressed and decompressed multiple times, resulting in degraded voice quality.

# Evolution from 2G to 3G



# Evolution from 2G to 3G

## Acronyms

- ◆ EDGE: Enhanced Data rate for GSM Evolution
- ◆ EGPRS: Enhanced GPRS
- ◆ UTRA: UMTS Terrestrial Radio Access
- ◆ WCDMA: Wideband CDMA
- ◆ FDD: Frequency Division Duplex
- ◆ TDD: Time Division Duplex
- ◆ CDD: Code Division Duplex



# EEE4121F-A

## Mobile and Wireless Networks

The greatest oak was once a little nut that  
held its ground.

Never quit!

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