UESTC4004
Digital Communications

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Lecture Overview

- Duplexing
  - FDD: Frequency division duplexing
  - TDD: Time division duplexing
- Multiples Access Schemes
  - FDMA : Frequency division Multiple Access
  - TDMA : Time division Multiple Access
  - SSMA : Spread spectrum Multiple Access

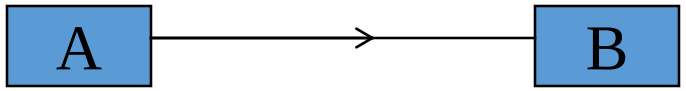
- Video lectures on Aula for additional support

Introduction

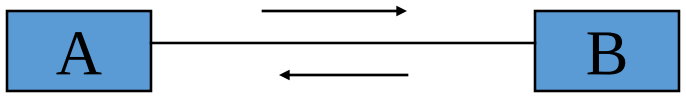
- Multiple access schemes are used to allow multiple users to share simultaneously a finite amount of radio spectrum
- Sharing of spectrum is required to increase capacity
- For high quality communication this sharing of spectrum should not degrade performance of the system
- duplexing generally required

Duplexing

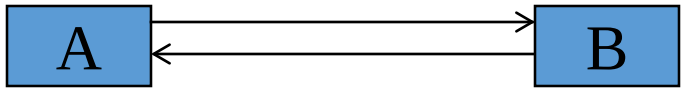
- To transmit and receive simultaneously: Possible using
  - frequency domain techniques
  - time domain techniques
- Classification of communication systems according to their connectivity
  - Simplex: ‘A’ is transmitter while ‘B’ is receiver throughout communication, e.g., radio



  - Half-duplex: A node can transmit as well as receive but can not transmit and receiver simultaneously, e.g., walkie-talkie

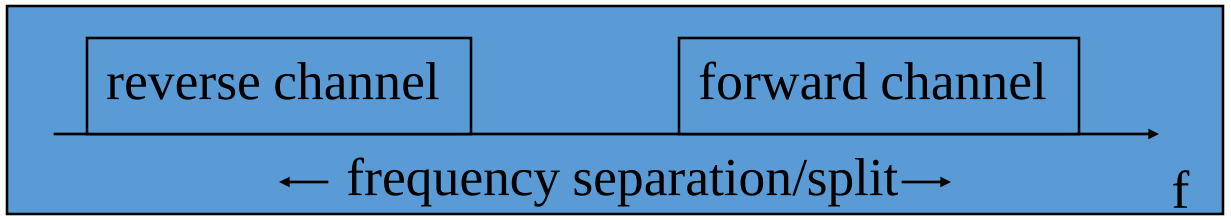


  - Full Duplex: Nodes can transmit and receive simultaneously, e.g., mobile phone



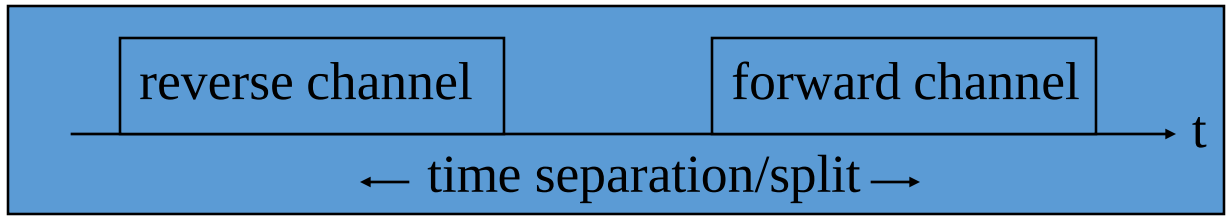
Frequency division duplexing (FDD)

- two bands of frequencies for every user
  - forward band or downlink (for traffic from Base station to mobile unit)
  - reverse band or uplink (for traffic from mobile unit to Base station)
- duplexer needed
- frequency separation between forward band and reverse band is constant throughout the system



Time division duplexing (TDD)

- uses different time slots for forward and reverse link
  - forward time slot
  - reverse time slot
- no duplexer is required (a simple switch can be used)
- Communication is not full-duplex



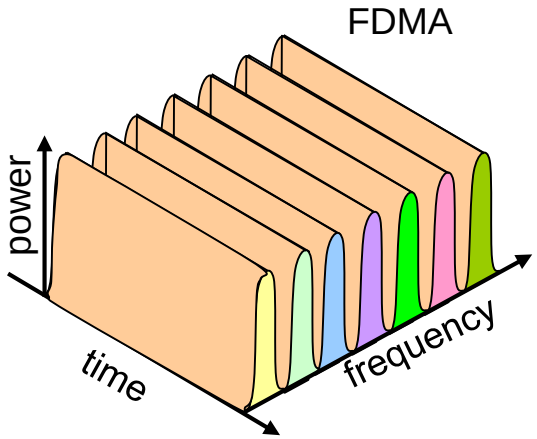
Trade-offs b/w FDD and TDD

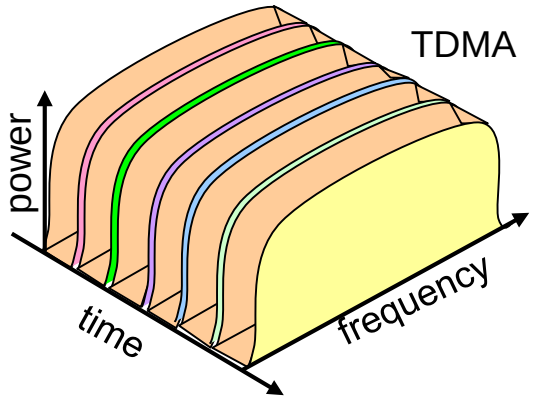
- FDD
  - Provides individual radio frequencies to each user
    hence, transceiver should work on two frequency bands
  - Frequency allocation must be carefully coordinated with Out-of-band users
  - Duplexer needed
- TDD
  - Single frequency hence simple transceiver
  - Duplexer not needed, a switch can do the job
  - There is time latency, communication is not full-duplex

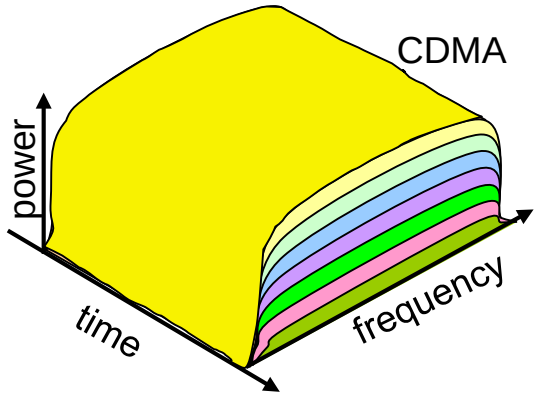
Multiple Access Techniques in Wireless Communication System

- Frequency division multiple access (FDMA)
- Time division multiple access (TDMA)
- Code division multiple access (CDMA)
- Space division multiple access (SDMA)

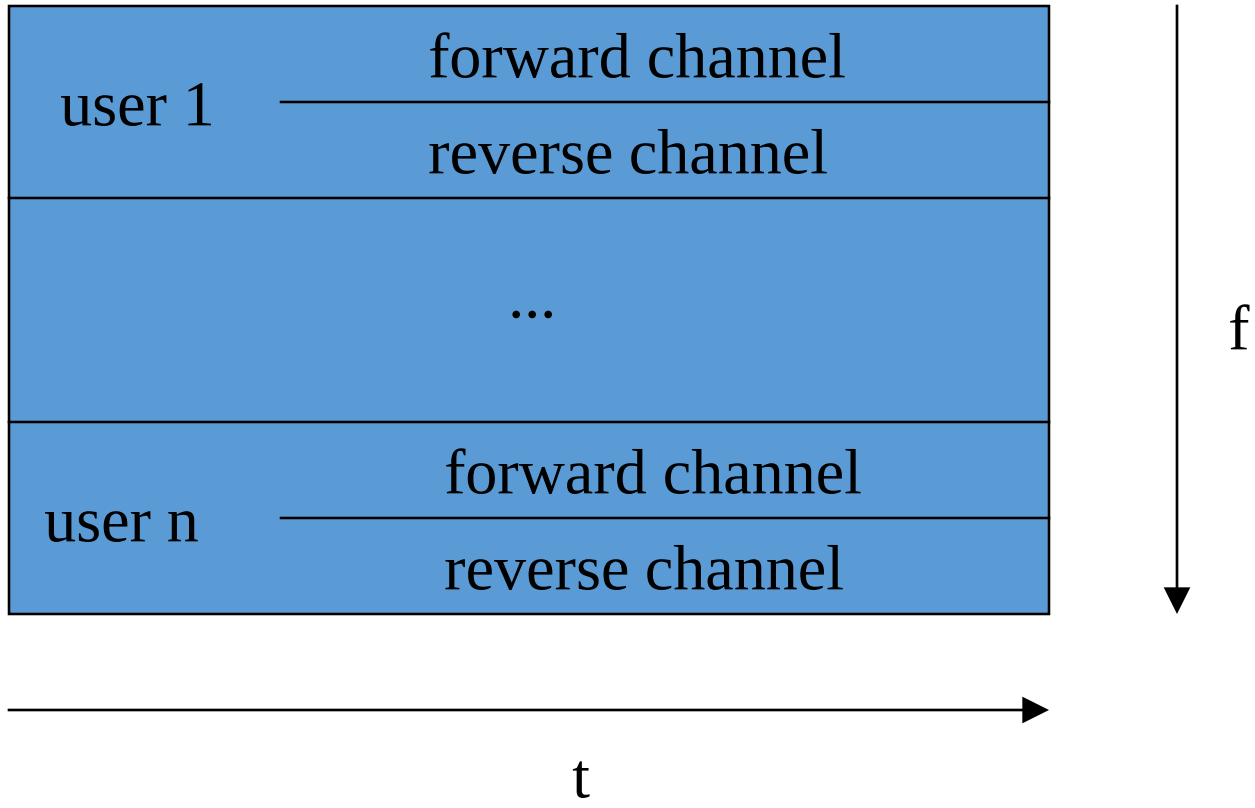
Multiple Access Techniques



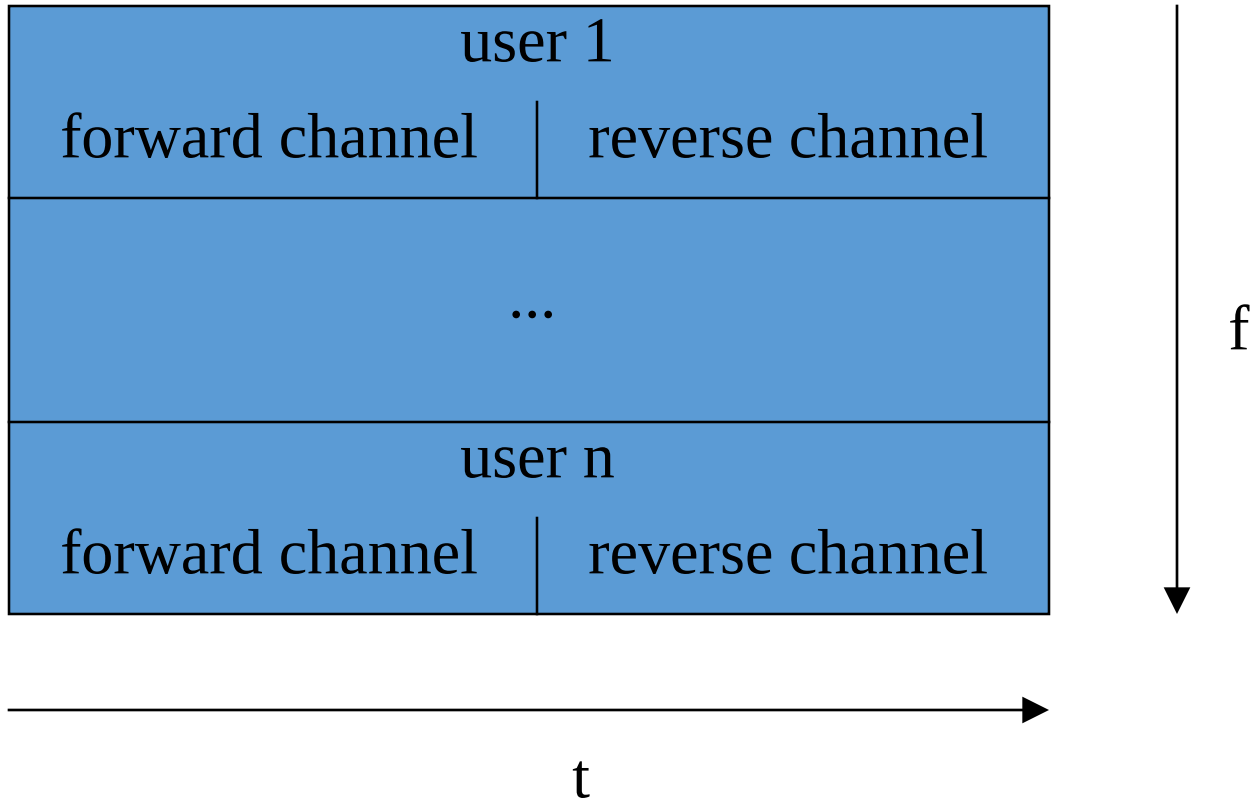




FDMA/FDD


user 1
forward channel
reverse channel
...
user n
forward channel
reverse channel
f
t

FDMA/TDD


user 1
forward channel
reverse channel
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user n
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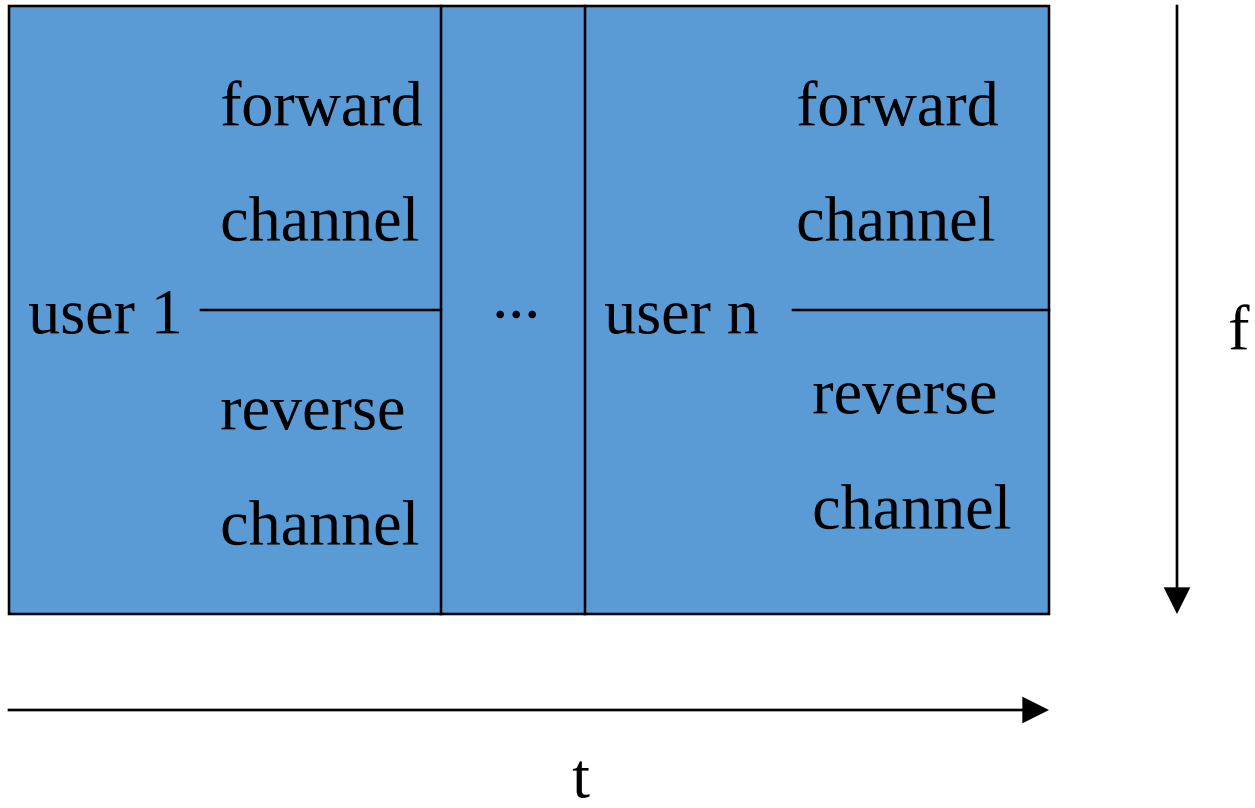
TDMA/FDD


forward
channel
user 1
reverse
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···
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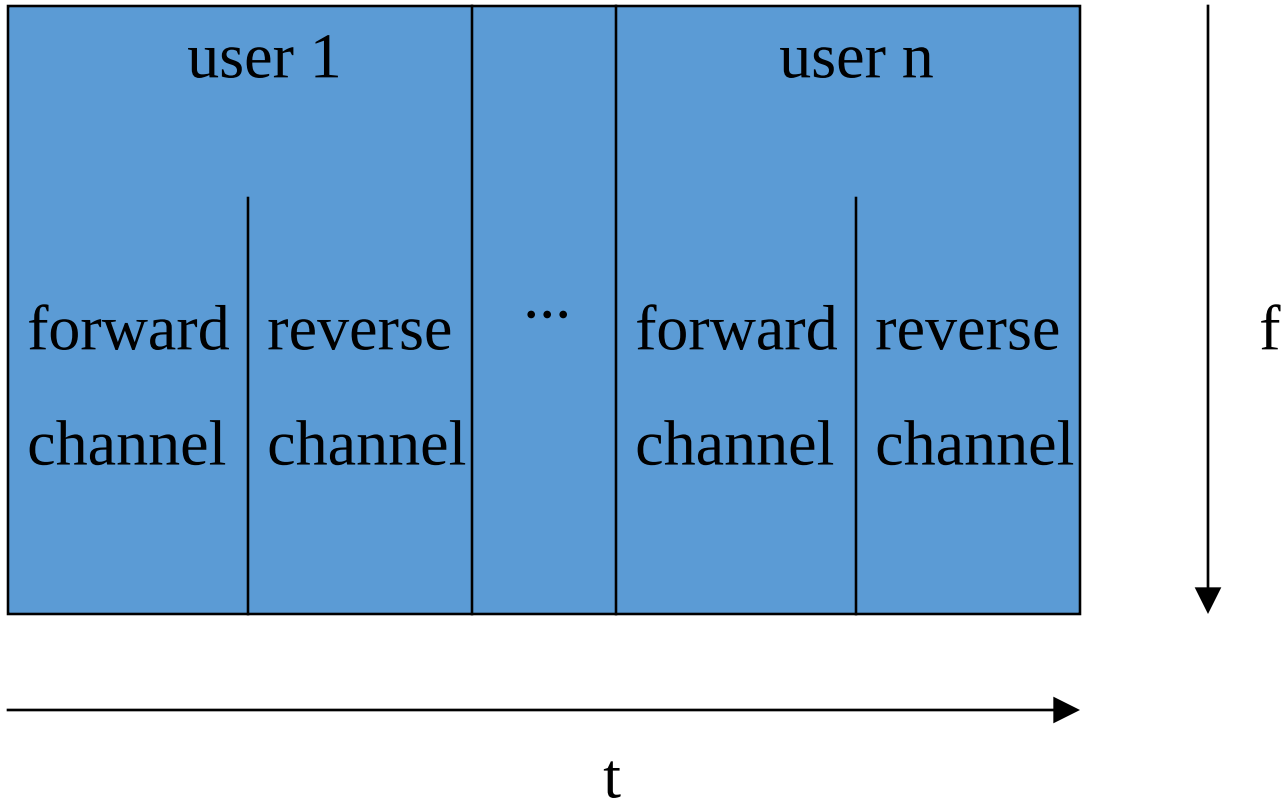
TDMA/TDD


user 1
user n
forward channel
reverse channel
...
forward channel
reverse channel
f
t

Multiple Access Techniques in use

Cellular System	Multiple Access Technique
Advanced Mobile Phone System (AMPS)	FDMA/FDD
Global System for Mobile (GSM)	TDMA/FDD
US Digital Cellular (USDC)	TDMA/FDD
Digital European Cordless Telephone (DECT)	FDMA/TDD
US Narrowband Spread Spectrum (IS-95)	CDMA/FDD

Frequency division multiple access FDMA

- one phone circuit per channel
- idle time causes wasting of resources
- simultaneously and continuously transmitting
- usually implemented in narrowband systems
- Complexity of FDMA mobile systems is lower compared to TDMA
- FDMA uses duplexers
- for example: AMPS is a FDMA system with bandwidth of 30 kHz

FDMA compared to TDMA

- fewer bits for synchronization
- fewer bits for framing
- higher costs for duplexer used in base station and subscriber units
- FDMA requires RF filtering to minimize adjacent channel interference

Time Division Multiple Access

- Time slots
- one user per slot
- Buffer and burst method
- Non-continuous transmission

Advantage:

Total bandwidth is utilized

Disadvantage:

Strict Burst Timing is required at the earth station

Features of TDMA

- a single carrier frequency for several users
- transmission in bursts
- handoff process much simpler (can listen when idle)
- Low battery consumption
- Bandwidth can be supplied on demand
- high synchronization overhead

Spread Spectrum Multiple Access (SSMA)

- SSMA uses Signals have transmission BW that is several orders of magnitude greater than the minimum required BW
- A Pseudo-noise sequence converts a narrow band signal to a wideband noise-like signal before transmission
- SSMA not BW efficient when used by a single user
- Many users can share the same BW without interfering with one another
- Type of SSMA techniques:
  - frequency hoped multiple access (FHMA)
  - Direct sequence multiple access (DS) or Code division multiple access (CDMA)

Frequency Hopped Multiple Access (FHMA)

- It is digital multiple access system
- Carrier frequencies of individual users varied in pseudorandom fashion with in a wideband channel
- Digital data broken into uniform sized bursts which are transmitted on different carriers
- Instantaneous BW of any one transmission burst is much smaller than the total spread BW
- Locally generated PN code is used to synchronize the receiver frequency with that of transmitter.
- Provides a High level of security
  - Fast frequency hopping system
  - Slow frequency hopping

CDMA

- Narrowband signals is multiplied by a very large bandwidth signal called the spreading signal.
- The spreading signal is pseudo noise code sequence that has a chip rate which is orders of magnitudes greater than data rate of the message
- All users use the same carrier frequency and transmit simultaneously
- Each user has its own pseudo random code word which is approximately orthogonal to other codewords

CDMA Example