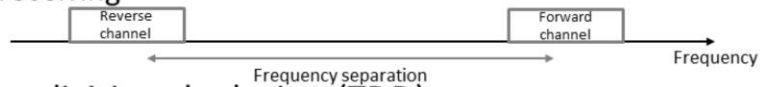


## **MULTIPLE ACCESS TECHNIQUES**

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## Why Multiple Access Schemes?

- Spectrum is limited, highly regulated, and expensive to own
  - Multiple access methods allow many (mobile) users to share simultaneously a finite amount of radio spectrum
- Frequency division duplexing (FDD)
  - Assign separate frequencies (channels) for transmitting and receiving



- Time division duplexing (TDD)
  - Assign separate time slots for transmitting and receiving



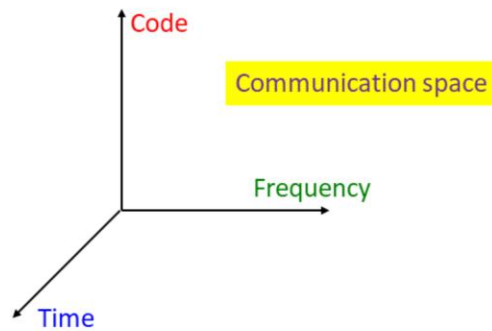
## Channel Partitioning

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- Four primary ways to partition the common medium (“air”) based on
  - Frequency
  - Time
  - Space
  - Coding

## Multiple Access Methods

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

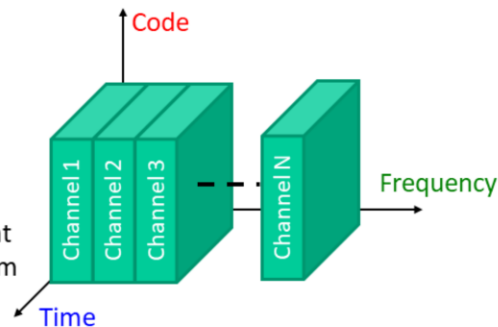


## Frequency Division Multiple Access (FDMA)

- FDMA assigns multiple individual channels (frequency bands) to individual users
  - Only the assigned user can use the channel even if it's not used for some time (but the call is still active)
- The number of channels supported by FDMA is

$$N_{FDMA} = \frac{B_t - 2B_{guard}}{B_c}$$

- $B_t$  is the total allocated spectrum
- $B_{guard}$  is the allocated guard band at the edges of the allocated spectrum
- $B_c$  is the channel bandwidth



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In the context of typical voice calls, some characteristics and properties of the FDMA method are:

- Each FDMA channel carries only one phone circuit at a time.
- After the assignment of a voice channel, the base station and the mobile transmit simultaneously.
- An FDMA channel that is not used, remains idle and cannot be used by other users to improve capacity, leading to wasted resources.
- The BWs of FDMA for phone conversations are relatively narrow (tens of kHz), usually implemented in narrowband systems.
- A mobile unit that supports FDMA requires duplexers since both the transmitter and receiver operate simultaneously.

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## Time Division Multiple Access (TDMA)

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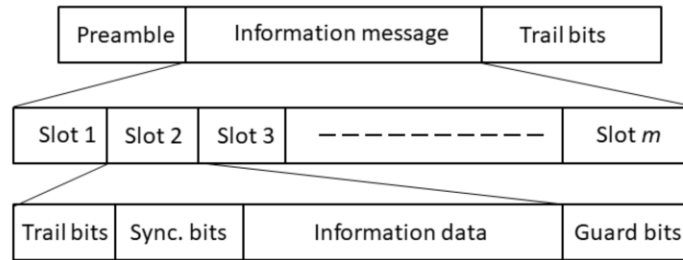
- TDMA splits the spectrum into time slots and each user uses one time slot to either transmit or receive
- The specific time slots are periodically repeated
- The time slots form a repeated TDMA frame

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In the context of typical voice calls, some characteristics and properties of the TDMA method are:

- In TDMA, a single frequency is shared among several users, where each user utilizes non-overlapping time slots. The number of slots within each frame depends on the modulation technique, available bandwidth, and other factors.
- Data transmission for users of a TDMA system is not continuous but comes into bursts, which leads to lower battery consumption, since the transmitter of the users can be switched off whenever no transmission occurs.
- TDMA uses different time slots for transmission and reception, thus duplexers are not required.
- The guard time should be minimized. If the transmitted signal at the edges of a time slot is suppressed sharply in order to shorten the guard time, the transmitted spectrum will expand resulting in interference to adjacent channels.
- Due to the burst transmissions, a high synchronization overhead is required in TDMA systems. Since TDMA transmissions are slotted, this requires synchronization of the receivers for each data burst. Moreover, guard slots are necessary to separate users, and this results in the TDMA systems having larger overheads compared to FDMA.
- An advantage of TDMA is that it is possible to allocate different numbers of time slots per frame to different users. This situation allows to assign different BW to different users based on priority demands.

## TDMA Frame Structure



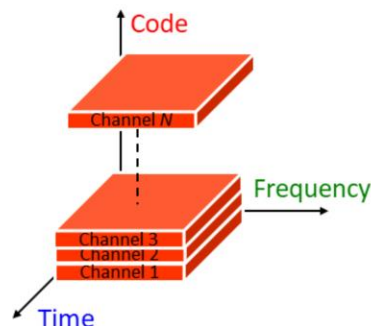
- Preamble contains address and synchronization information used by the base station and user for identification
- Guard time allows synchronization of the receivers between slots and frames
- Different TDMA standards can use different frame structures
- The number of channel slots supported by a TDMA system is

$$N_{TDMA} = \frac{m(B_t - 2B_{guard})}{B_c}$$

- where  $m$  is the maximum number of users supported on each radio channel

## Code Division Multiple Access (CDMA)

- In CDMA, all users use the same frequency and may transmit at the same time
- Each user has a specific pseudorandom codeword which is almost orthogonal to all other codewords
- The receiver must know the corresponding codeword used by the appropriate transmitter



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In the context of typical voice calls, some characteristics and properties of the CDMA method are:

- In a CDMA system, many users share the same frequency, where time or frequency division duplexing can be utilized.
- In contrast to FDMA or TDMA, CDMA has a soft capacity limit. Increasing the number of users in a CDMA system raises the noise floor linearly. Therefore, there is no absolute limit on the number of users in CDMA. Rather, the system performance gradually drops for all users with an increasing number of users while it improves if the number of users decreases.
- The near-far problem occurs at a CDMA receiver if an undesired user has a high detected power as compared to the desired user. Thus, power control is enforced by the base station although out of cell users can still cause substantial interference.