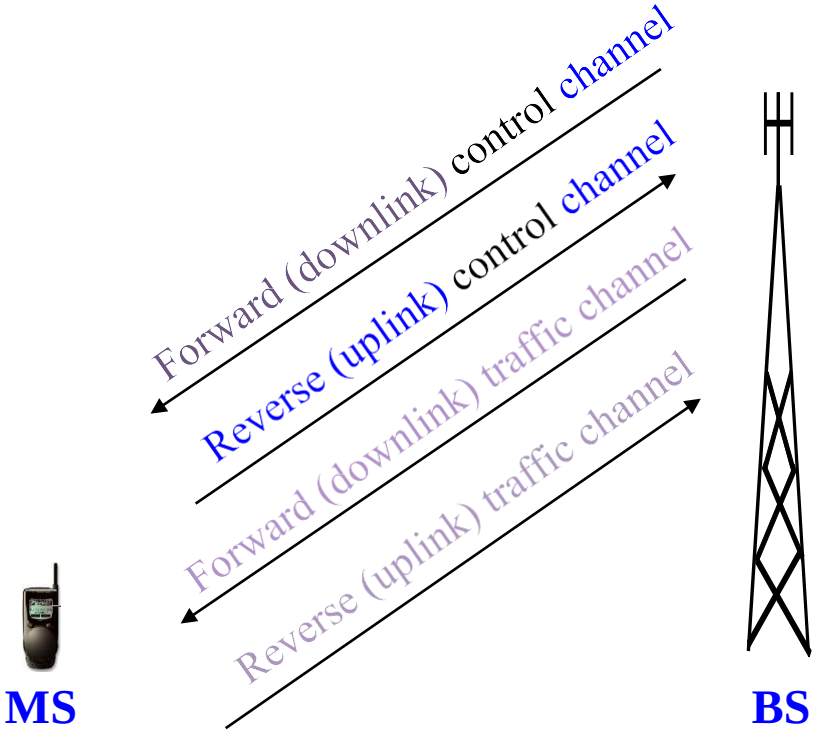
Multiple Access Techniques

- many users at same time
- share a finite amount of radio spectrum
- high performance
- duplexing generally required
  - frequency domain
  - time domain

Multiple Access Techniques

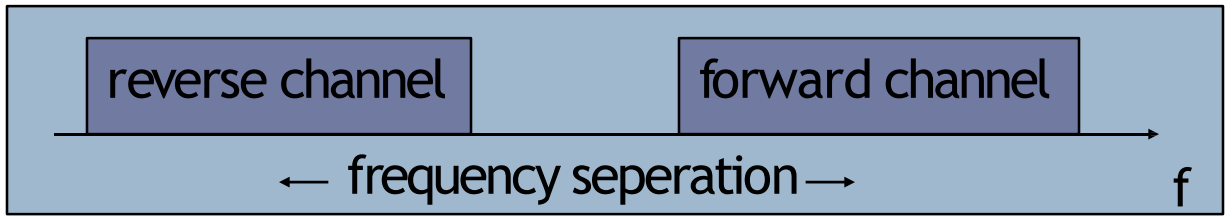
- Duplex communications = simultaneous 2-way communications
- Duplex communications requires
  - Forward (downlink) channel
  - Reverse (uplink) channel



Multiple Access Techniques

Frequency division duplexing (FDD)

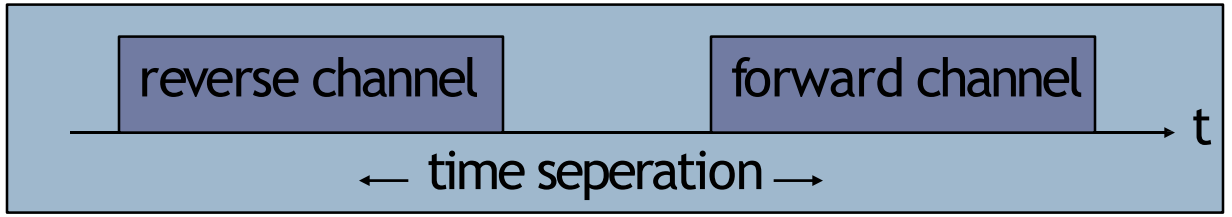
- two bands of frequencies for every user
- forward band
- reverse band
- duplexer needed
- frequency separation between forward band and reverse band is constant



Multiple Access Techniques

Time division duplexing (TDD)

- uses time for forward and reverse link
- multiple users share a single radio channel
- forward time slot
- reverse time slot
- no duplexer is required



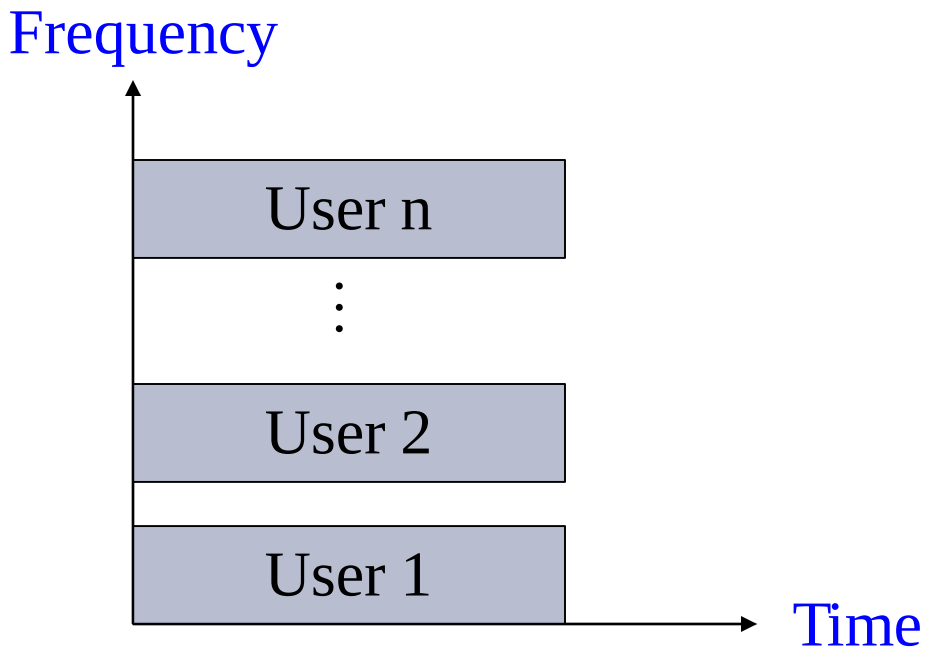
Multiple Access Techniques

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

Grouped as:

- narrowband systems
- wideband systems

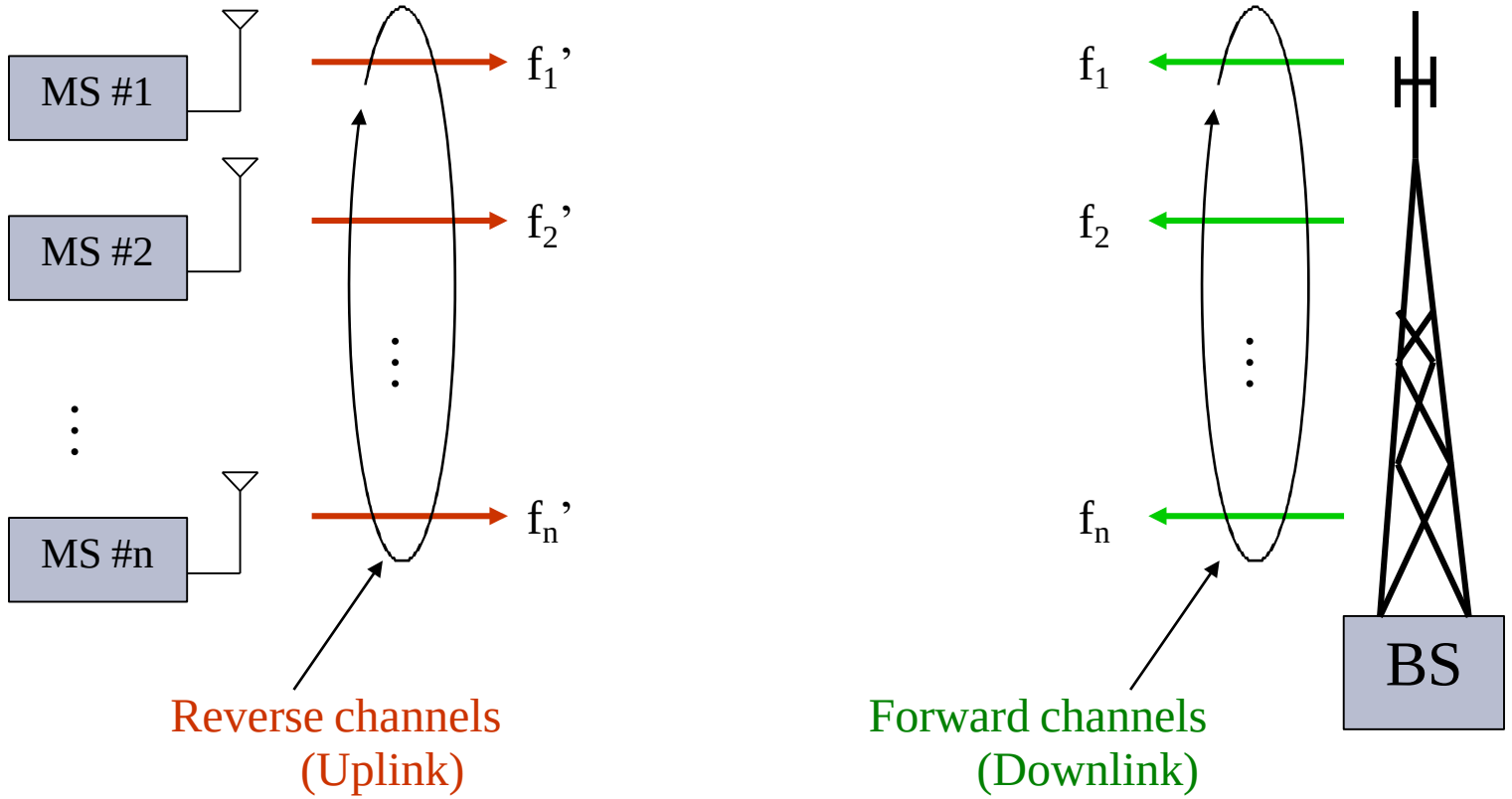
Frequency Division Multiple Access (FDMA)



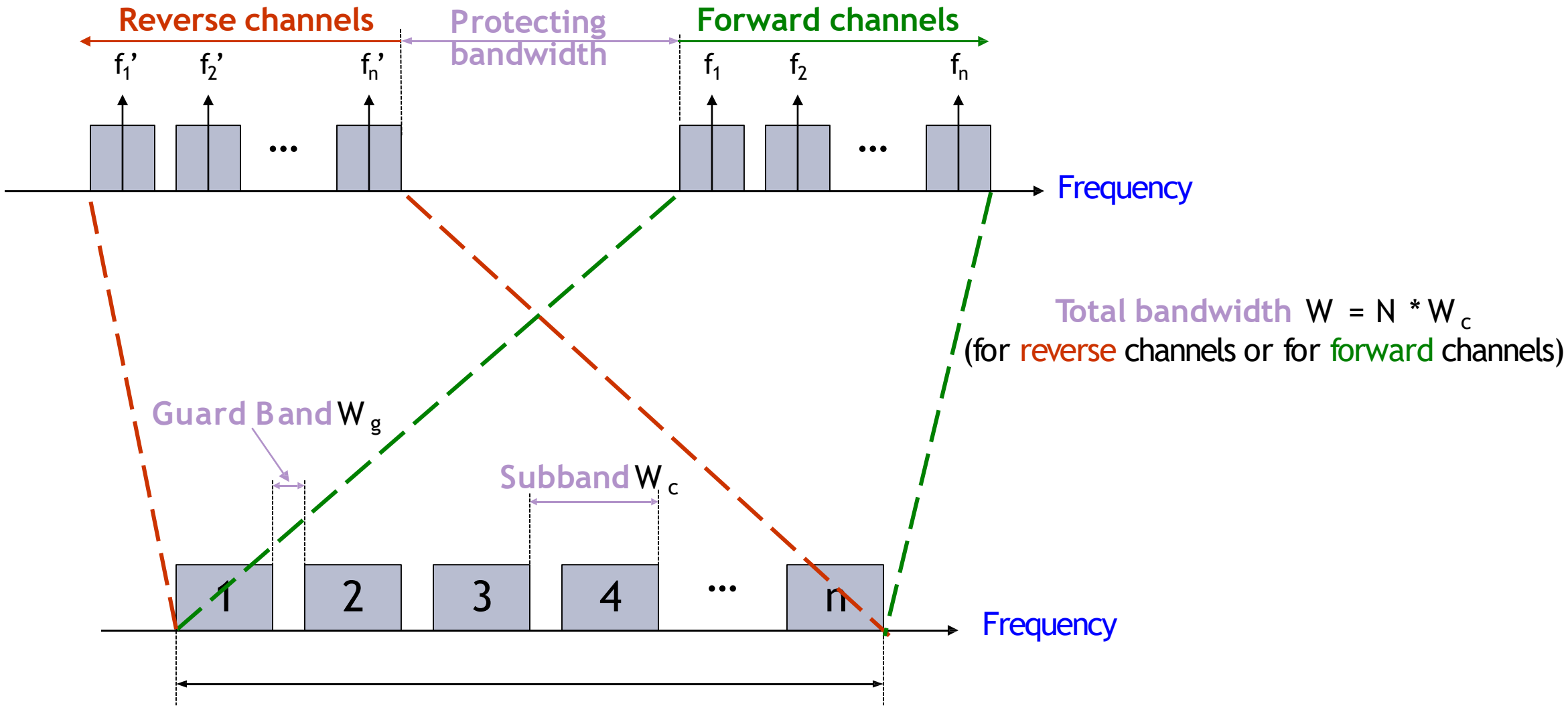
- Separate (unique) carrier frequency per user
- All 1G (first-generation) systems use FDMA

Basic Structure of a FDMA System

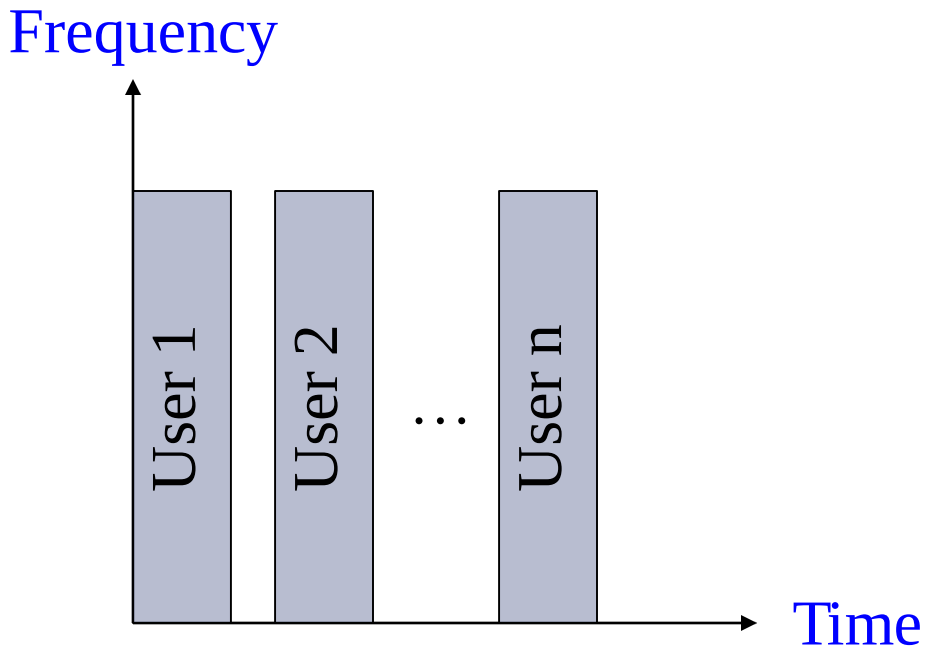
- - 1 BS and *n* MSs - f_i' and f_i – for MS #i



FDMA Channel Structure

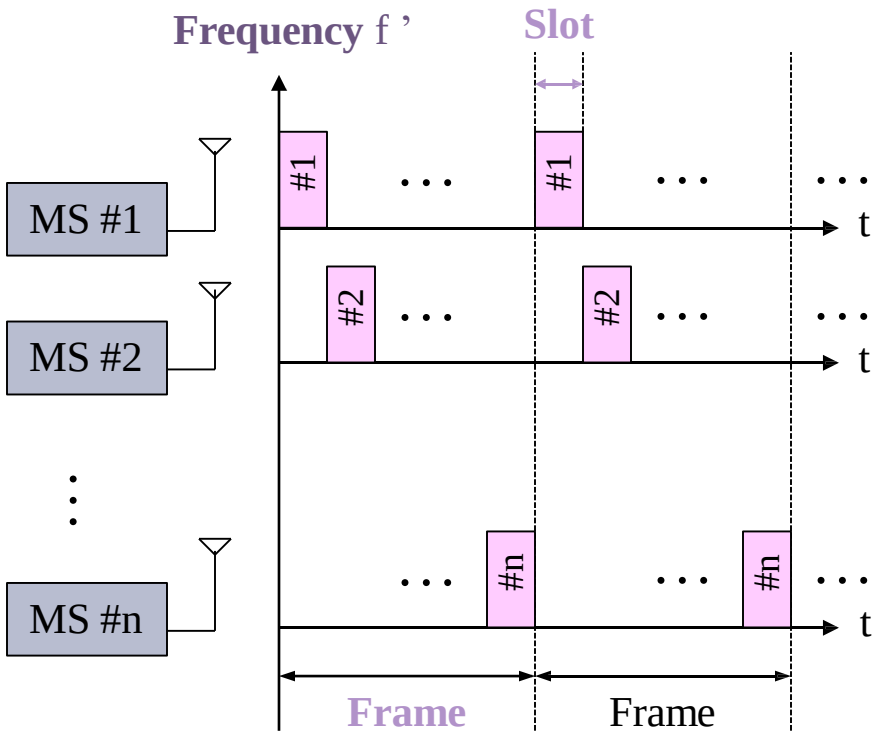


Time Division Multiple Access (TDMA)

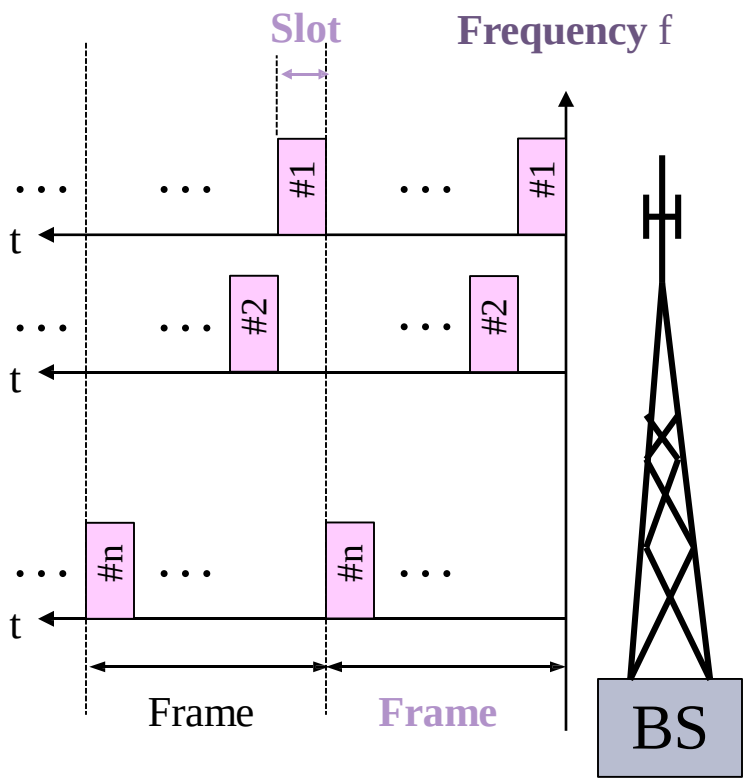


- Separate (unique) time slot per user
  - The same carrier (frequency) split into time slots
  - Each frequency efficiently utilized by multiple users
- Most of 2G systems use TDMA

Basic Structure of TDMA

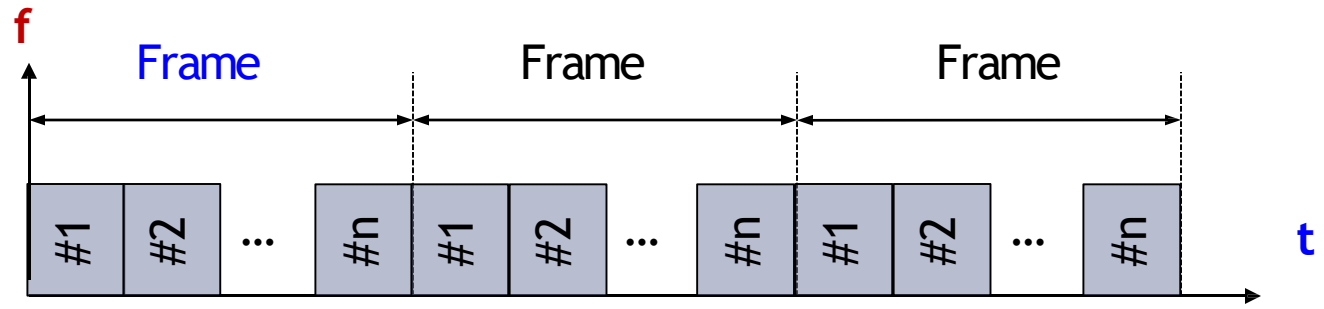


Reverse channels
(Uplink)

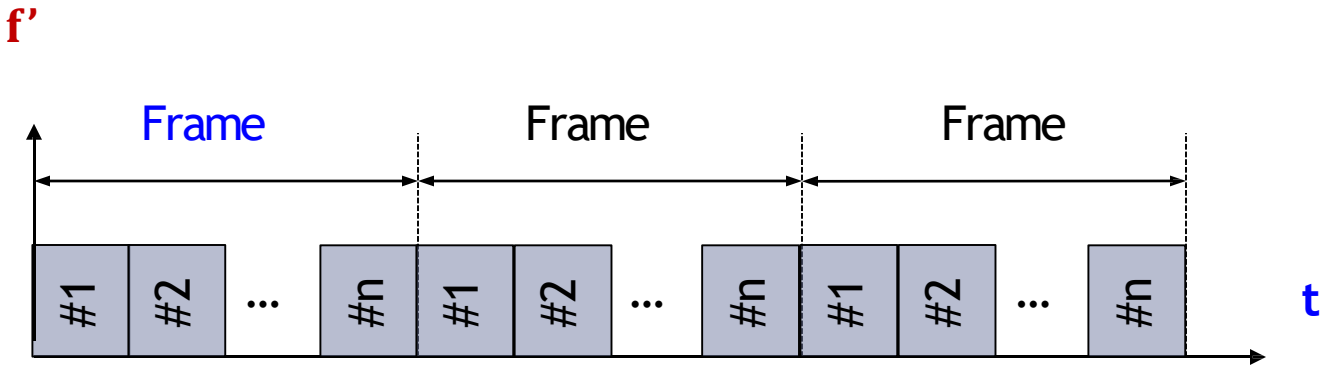


Forward channels
(Downlink)

Channel Structure in TDMA/FDD System

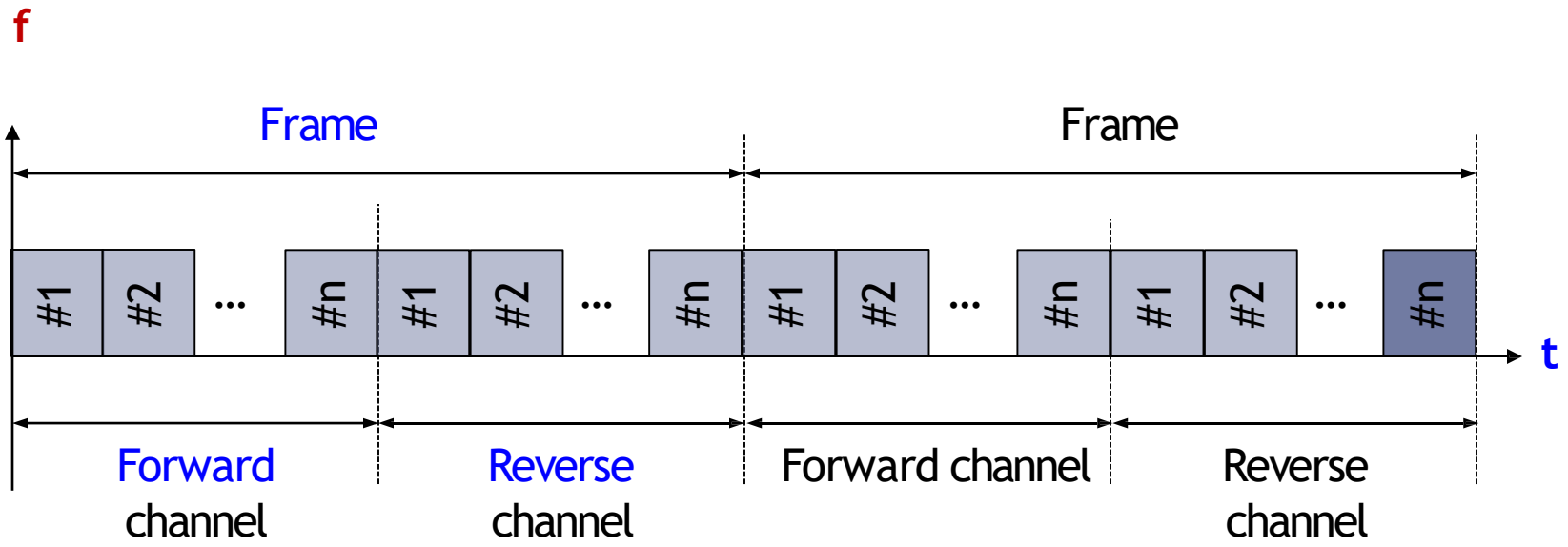


(a) All forward channels on frequency **f**



(a) All reverse channels on different frequency **f'**

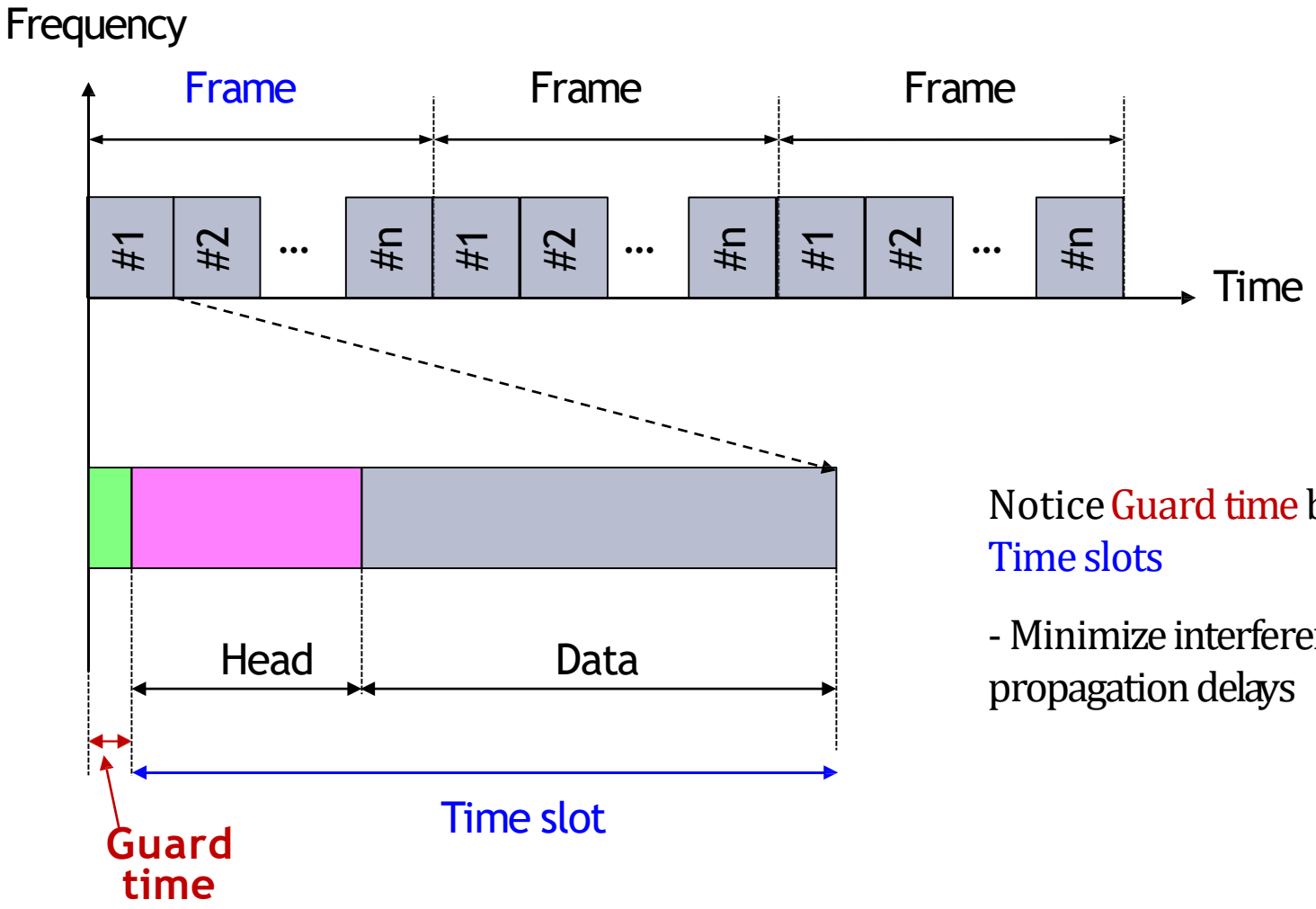
Channel Structure in TDMA/TDD System



(a) All forward and all reverse channels on the same frequency **f**

(1st half of each frame used for forward channels, 2nd half – for reverse channels)

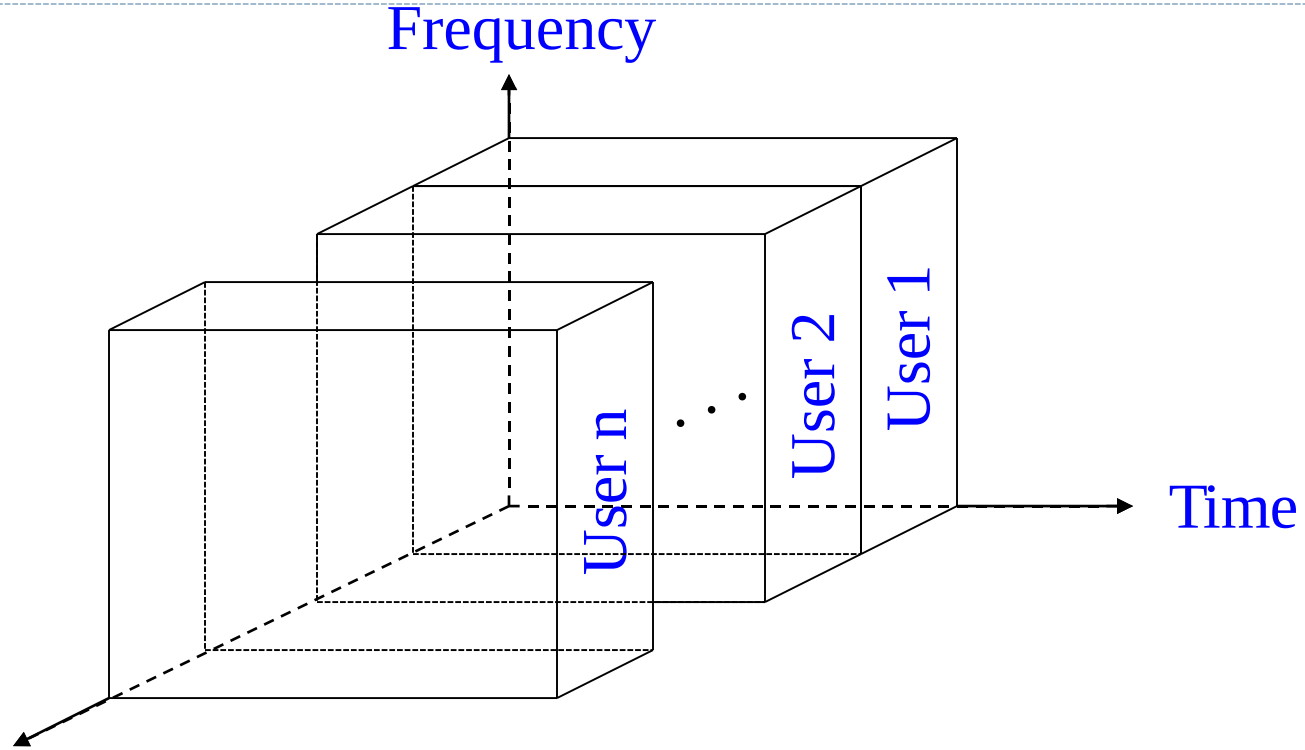
TDMA Frame Structure



Notice Guard time between Time slots

- Minimize interference due to propagation delays

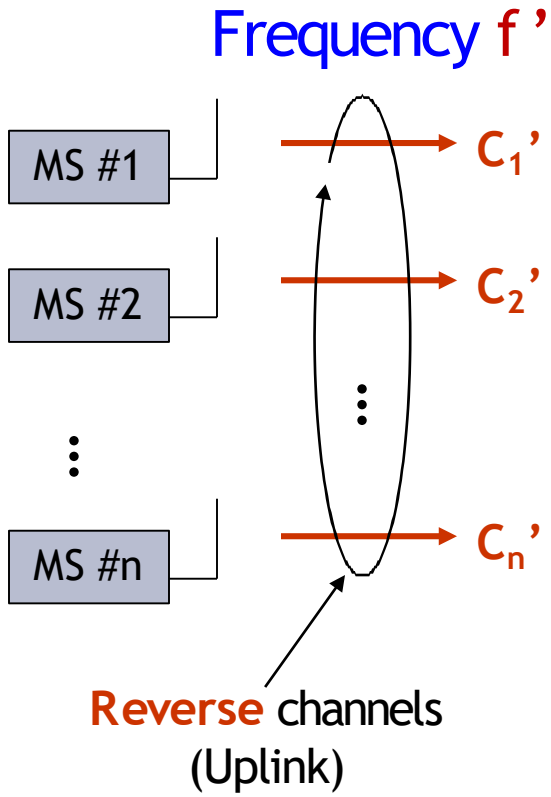
Code Division Multiple Access (CDMA)

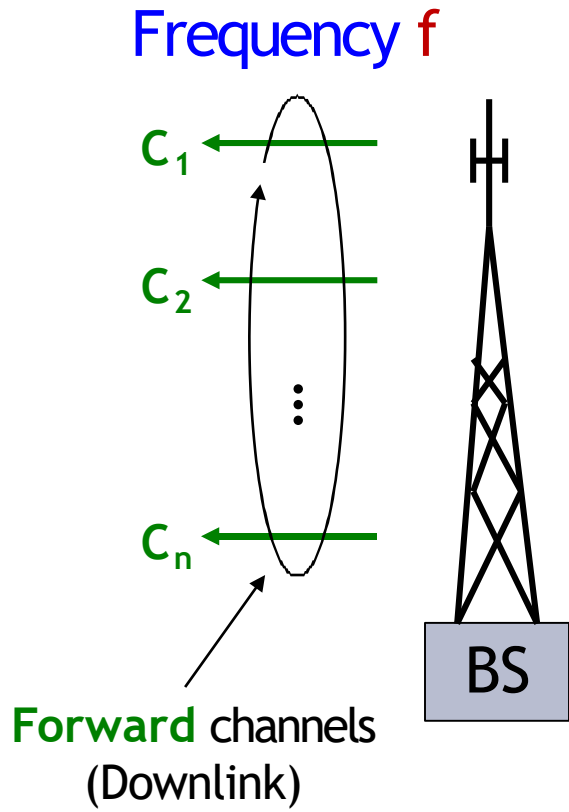


- Separate (unique) code per user
  - Code sequences are orthogonal **Code**
  - Different users can use same frequency simultaneously (see Fig above)
- Some 2G systems use CDMA /Most of 3G systems use CDMA

Structure of a CDMA System (with FDD)

- **FDD** (frequency division duplexing) since f for all forward channels, and f' for all reverse channels
- C_i = i-the code
- $C_i' \times C_j' = 0$, i.e., C_i' and C_j' are orthogonal codes on f'
- $C_i \times C_j = 0$, i.e., C_i and C_j are orthogonal codes on f

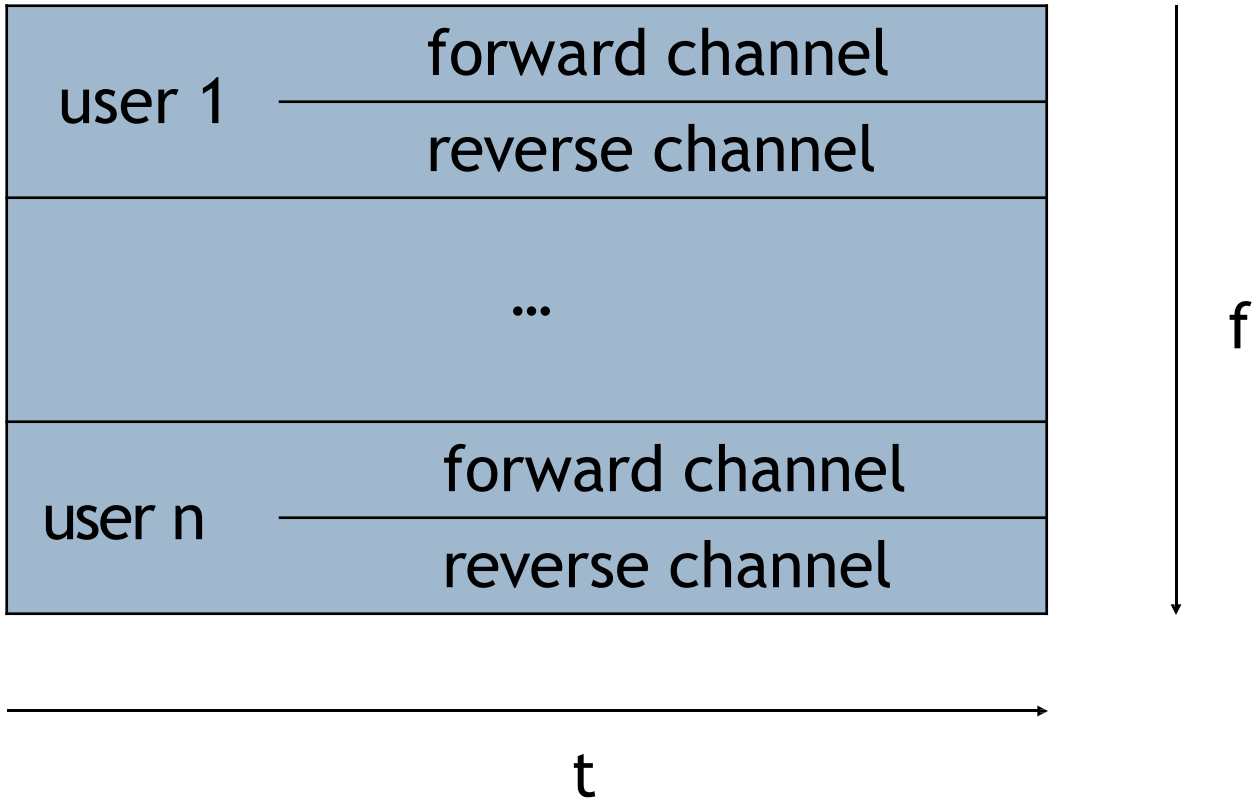




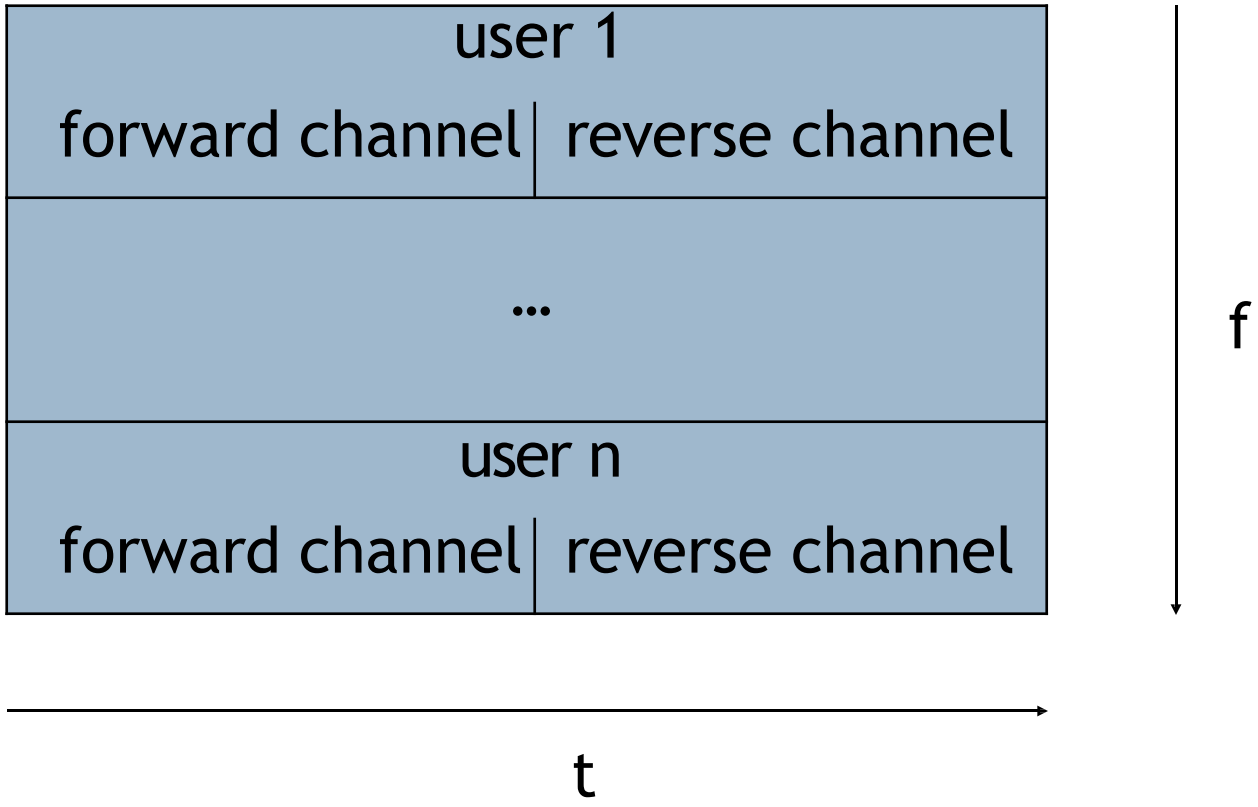
Narrowband Systems

- large number of narrowband channels
- usually FDD
- Narrowband FDMA
- NarrowbandTDMA
- FDMA/FDD
- FDMA/TDD
- TDMA/FDD
- TDMA/TDD

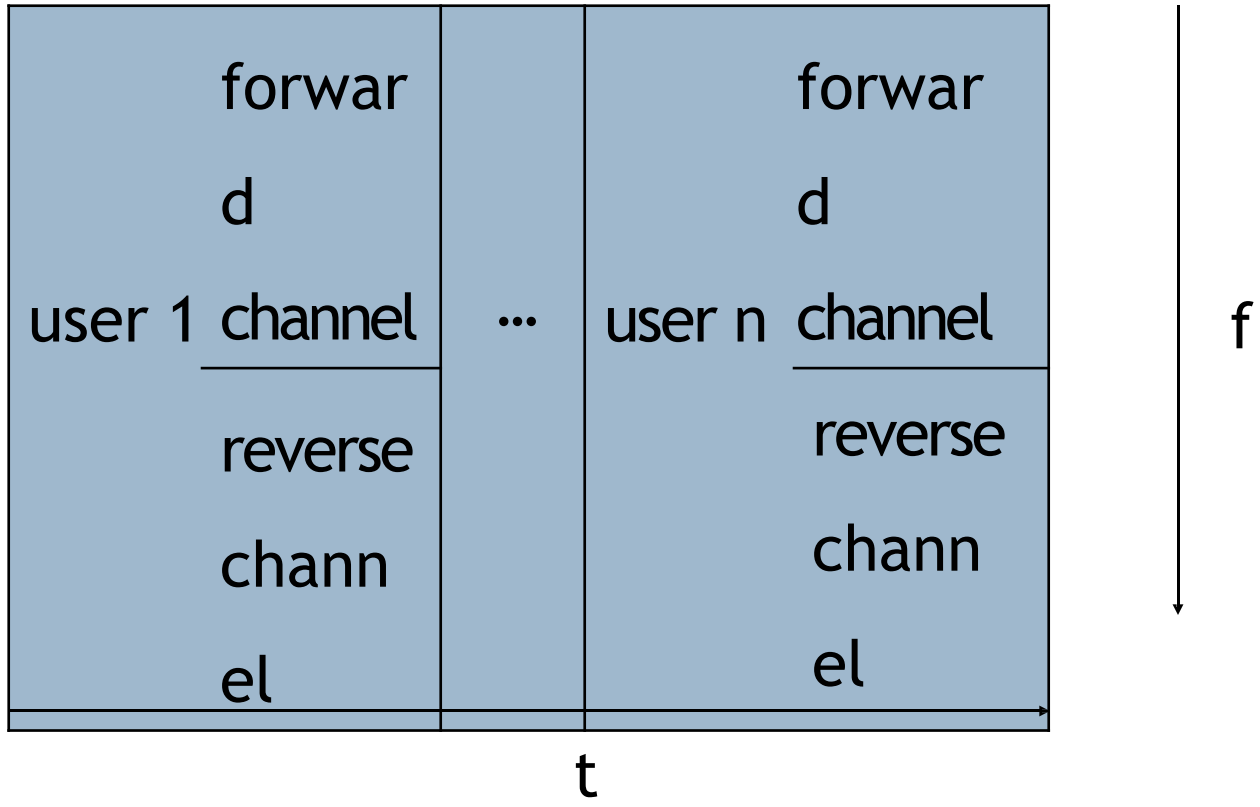
Logical separation FDMA/FDD



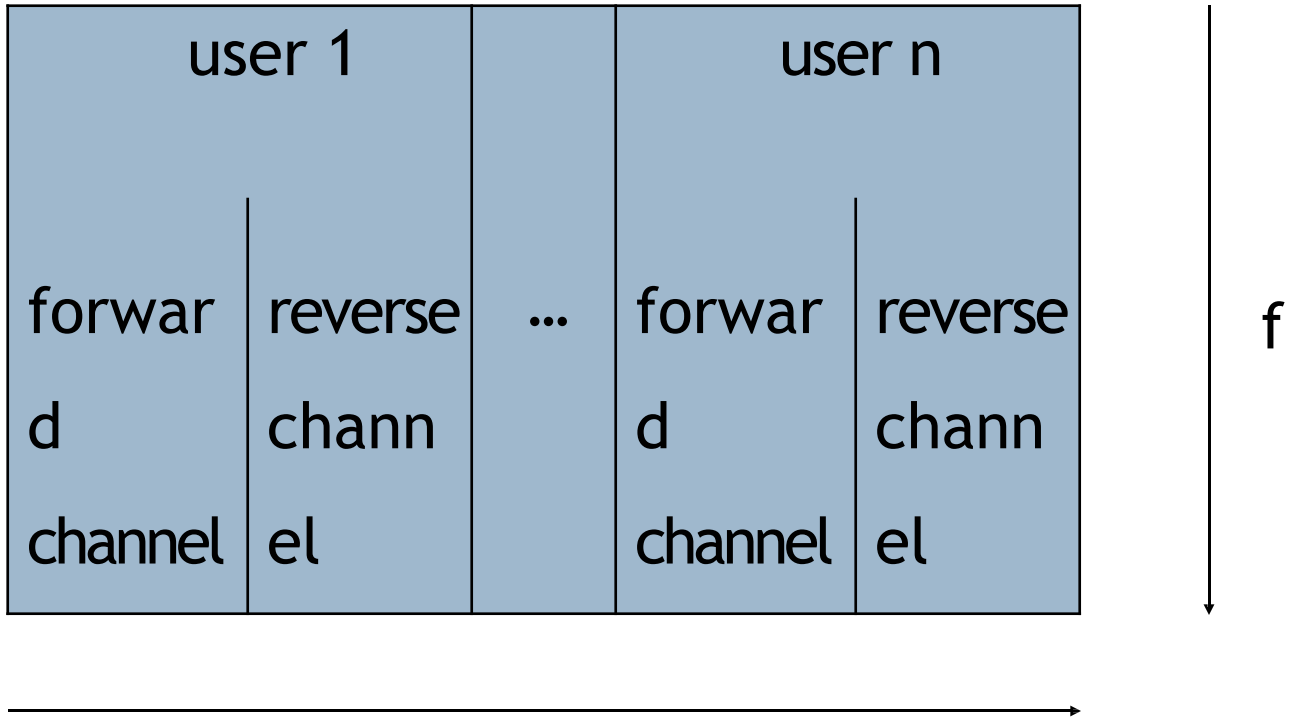
Logical separation FDMA/TDD



Logical separation TDMA/FDD



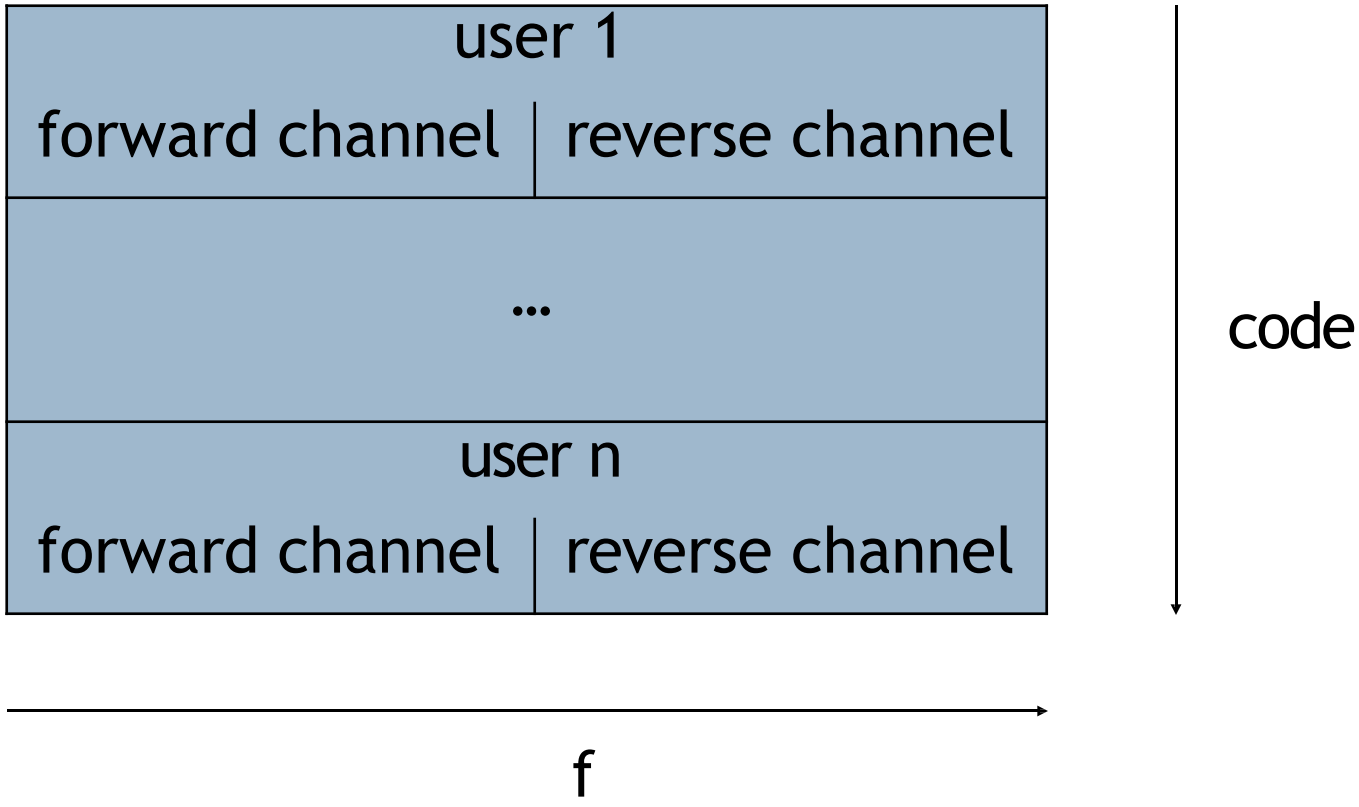
Logical separation TDMA/TDD



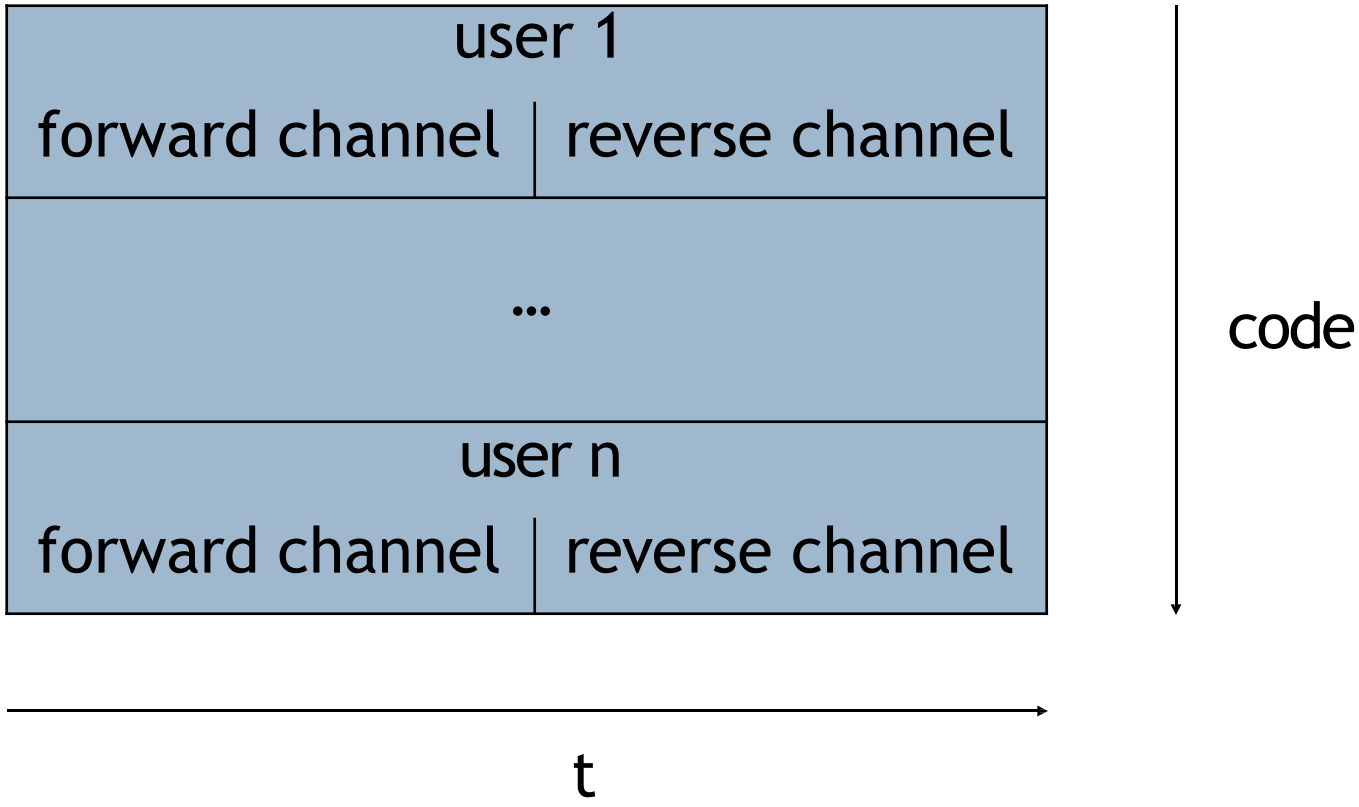
Wideband systems

- large number of transmitters on one channel
- TDMA techniques
- CDMA techniques
- FDD or TDD multiplexing techniques
- TDMA/FDD
- TDMA/TDD
- CDMA/FDD
- CDMA/TDD

Logical separation CDMA/FDD



Logical separation CDMA/TDD



Comparison

S.No	Parameter	FDMA	TDMA	CDMA
1.	Data Rates	Low	Medium	High
2.	Mode of Data	Continuous Signal	Signal in bursts	Digital Signal
3.	Capacity of the system	Low	Medium	Large
4.	Cost	High	Low	Installation cost is high but operating cost is lowest.

Comparison

5.	Handoff	Hard	Hard	Soft
6.	Flexibility	Low	Moderate	High
7.	Technique	Sharing of overall bandwidth of satellite transponder	Sharing of time of the satellite transponder	Sharing of bandwidth and time both
8.	Synchonization	No synchronization is required.	Time synchronization is essential.	No synchronization is required.
9.	Code Word	No code word is required.	No code word is required.	Code words are required by the ground station.

Summary

- Generation of PN sequence and its properties
- Direct sequence spread spectrum
  - Processing gain, Probability of error, Anti-jam characteristics
- Frequency hopped spread spectrum
  - Slow and fast frequency hopping
- Multiple access techniques - TDMA, FDMA, CDMA