EEE 367
Telecommunication Engineering

Multiplexing and Multiple Access

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Introduction

•Under the simplest conditions, a medium can carry only one signal at any moment in time

•For multiple signals to share one medium, the medium must somehow be divided, giving each signal a portion of the total bandwidth

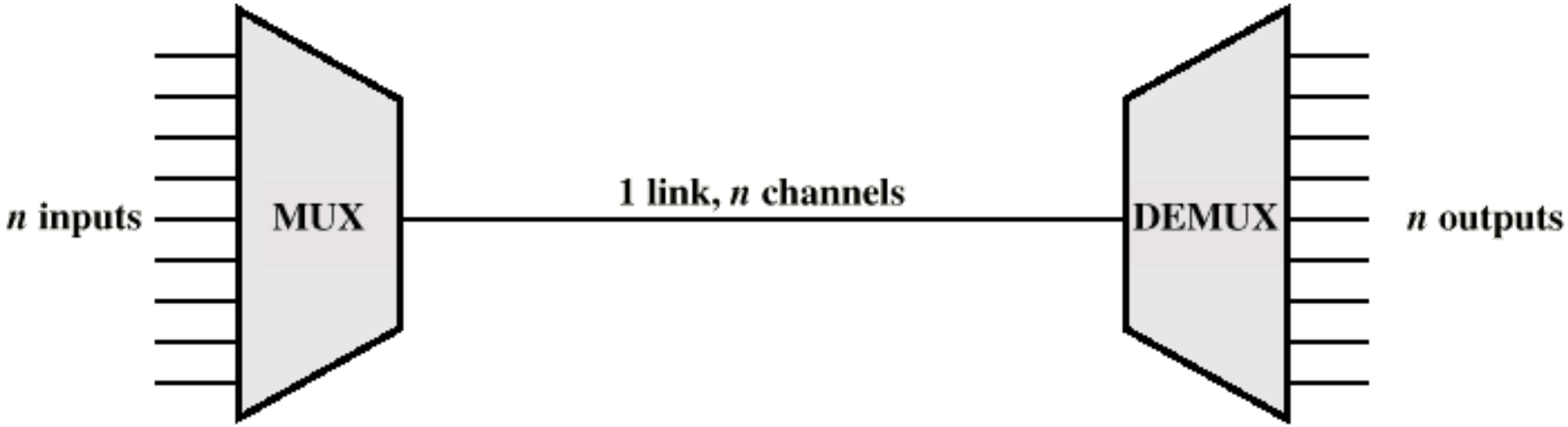
•The current techniques that can accomplish this include frequency division multiplexing, time division multiplexing, wavelength division multiplexing etc.

Multiplexing

- ***Multiplexing*** **is the transmission of information (in any form) from one or more source to one or more destination over the same transmission medium (facility).**
- Although transmissions occur at the same facility, they do not necessarily occur at the same time or occupy the same bandwidth.
- The transmission line may be a metallic wire pair, a coaxial cable, a PCS mobile telephone, a terrestrial microwave radio system, a satellite microwave system or an optical fiber cable.

Multiplexing

- Two or more simultaneous transmissions on a single circuit.



Multiple Access

- *Multiple Access* is a technique where by many subscribers or local stations can share the use of a communication channel at the same time. Therefore, a multiple access technique permits the communication resources of the channel to be shared by a large number of users.
- Simply, **Multiplexing is a technique and Multiple Access is a way to use this technique**.

Multiple Access

Any good multiple access protocol should have the following properties

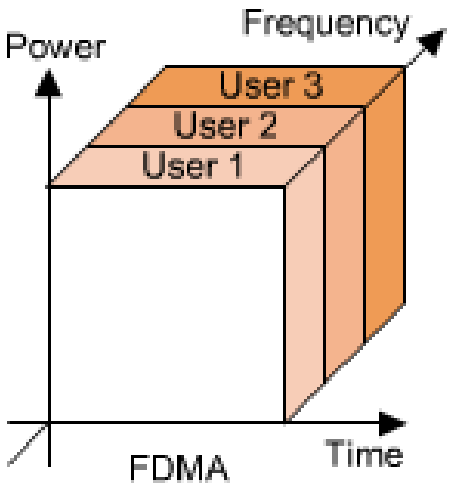
- To share a common transmission channel among several users in the system.
- The protocol should perform the allocation such that the transmission medium is used effectively.
- The allocation should be fair toward any users. Each should receive the same allocated capacity.
- The protocol should be flexible in allowing different types of traffic (voice or data).
- The protocol should be stable.

Types of Multiplexing

- ✓ Frequency Division Multiplexing
- ✓ Wavelength Division Multiplexing
- ✓ Time Division Multiplexing
- ✓ Statistical Time Division Multiplexing
- ✓ Code Division Multiplexing etc.

FDMA

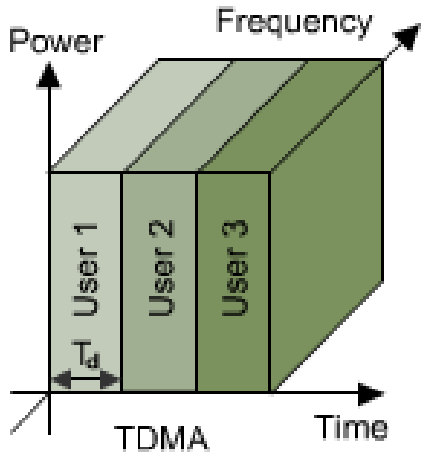
- Frequency Division Multiple Access (FDMA) splits the available frequency band into smaller fixed frequency channels. Each transmitter or receiver uses a separate frequency. This technique has been used since around 1900 and is still in use today. Transmitters are narrowband or frequency-limited. A narrowband transmitter is used along with a receiver that has a narrowband filter so that it can demodulate the desired signal and reject unwanted signals, such as interfering signals from adjacent radios.



FDMA is a basic technology in the analog Advanced Mobile Phone System (AMPS). With FDMA, each channel can be assigned to only one user at a time. FDMA is also used in the Total Access Communication System (TACS).

TDMA

- Time-division multiplexing involves separating the transmitters in time so that they can share the same frequency. The simplest type is Time Division Duplex (TDD). This multiplexes the transmitter and receiver on the same frequency. TDD is used, for example, in a simple two-way radio where a button is pressed to talk and released to listen. This kind of time division duplex, however, is very slow. Modern digital radios like CT2 and DECT use Time Division Duplex but they multiplex hundreds of times per second. TDMA (Time Division Multiple Access) multiplexes several transmitters or receivers on the same frequency.

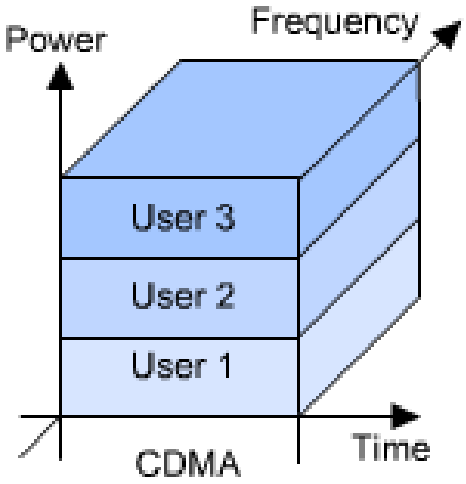


TDMA is utilized by Digital-Advanced Mobile Phone System (D-AMPS) and Global System for Mobile communication (GSM).

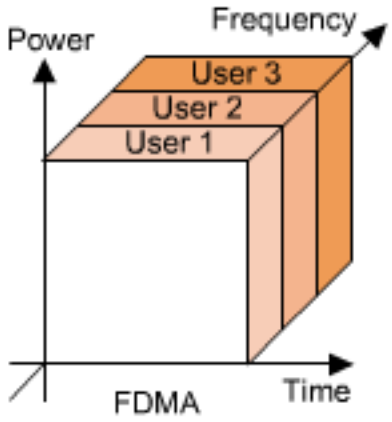
- In **Time Division Multiple Access (TDMA)**, it makes use of the same frequency spectrum but allows more users on the same band of frequencies by dividing the time into “slots” and shares the channel between users by assigning them different time slots.

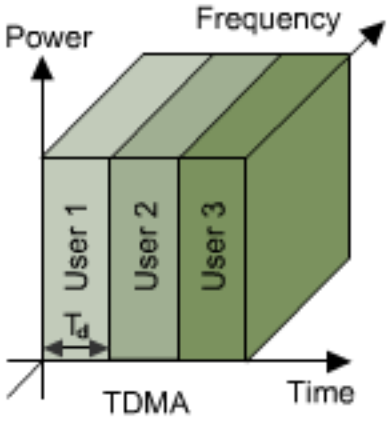
CDMA

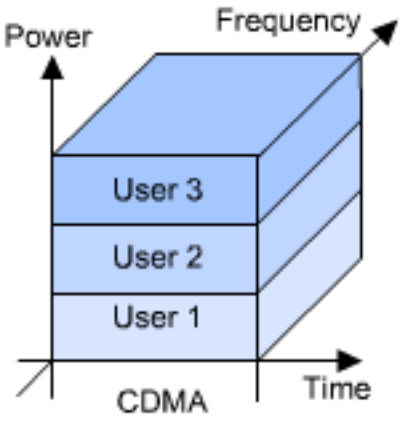
- CDMA (Code Division Multiple Access)
  - all terminals send on the same frequency probably at the same time and can use the whole bandwidth of the transmission channel
  - each sender has a unique random number, the sender XORs the signal with this random number
  - the receiver can "tune" into this signal if it knows the pseudo random number, tuning is done via a correlation function
- Disadvantages:
  - higher complexity of a receiver (receiver cannot just listen into the medium and start receiving if there is a signal)
  - all signals should have the same strength at a receiver
- Advantages:
  - all terminals can use the same frequency, no planning needed
  - huge code space (e.g. 2^{32}) compared to frequency space
  - interferences (e.g. white noise) is not coded
  - forward error correction and encryption can be easily integrated


Power
Frequency
User 3
User 2
User 1
CDMA
Time

Brief Comparison…







Frequency Division Multiple Access

- when the subscriber enters another cell a unique frequency is assigned to him; used in analog systems

Time Division Multiple Access

- each subscriber is assigned a time slot to send/receive a data burst; is used in digital systems

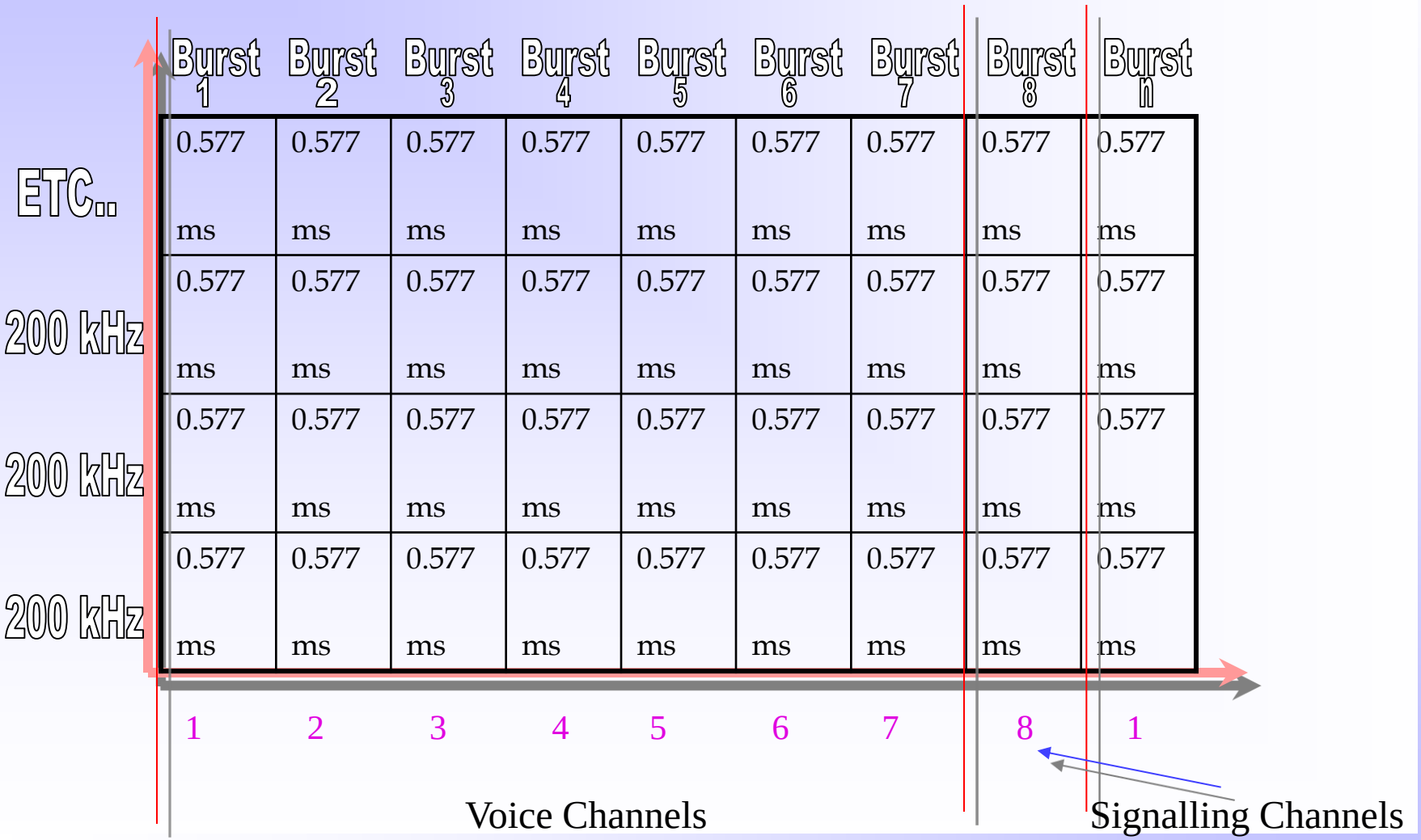
Code Division Multiple Access

- each subscriber is assigned a code which is used to multiply the signal sent or received by the subscriber

FDMA + TDMA

- A combination of FDMA/TDMA can be used. For example, in **GSM systems**. The traffic is burst onto the channel at a specific periods.
- With this combination, more channels can be used with less interference.
- How?

FDMA+TDMA in GSM




Thank you