CS8601 –MOBILE COMPUTING

UNIT 1

INTRODUCTION

1.3. Multiplexing:

- Multiplexing describes **how several users can share a medium with minimum or no interference**
- It is concerned with **sharing the frequency range amongst the users**
- **Bands are split into channels**
- Four main ways of assigning channels
    - **Space Division Multiplexing (SDM)** : allocate according to location
    - **Time Division Multiplexing (TDM):** allocate according to units of time
    - **Frequency Division Multiplexing (FDM):** allocate according to the frequencies
    - **Code Division Multiplexing (CDM)** : allocate according to access codes **Guard Space**: gaps between allocations

A. *Space division multiplexing*

- This is the basis of frequency reuse
- Each physical space is assigned channels
- Spaces that don't overlap can have the same channels assigned to them
- **Example: FM radio stations in different countries**

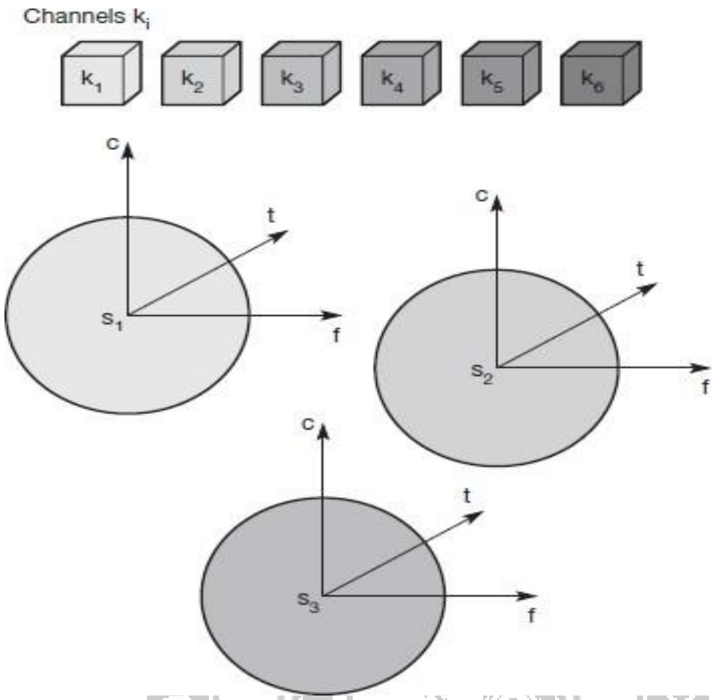
This multiplexing scheme is used, for example, at FM radio stations where the transmission range is limited to a certain region, many radio stations around the world can use the same frequency without interference

Below figure shows six channels ki and introduces a three dimensional coordinate system. This system shows the dimensions of code c, time t and frequency f. For this first type of multiplexing, **space division multiplexing (SDM)**, the (three dimensional) space si is also shown. Here space is represented via circles indicating the interference range

For the remaining channels (k4 to k6) three additional spaces would be needed. In our highway example this would imply that each driver had his or her own lane.

Drawback

Although this procedure clearly represents a **waste of space**, this is exactly the principle used by the old analog telephone system: each subscriber is given a separate pair of copper wires to the local exchange. In wireless transmission, **SDM implies a separate sender for each communication channel with a wide enough distance between senders**.



B. ***Frequency division multiplexing:***

- **Separation of the whole spectrum into smaller non overlapping frequency bands (guard spaces are needed)**
- **A channel gets a certain band of the spectrum for the whole time – receiver has to tune to the sender frequency**

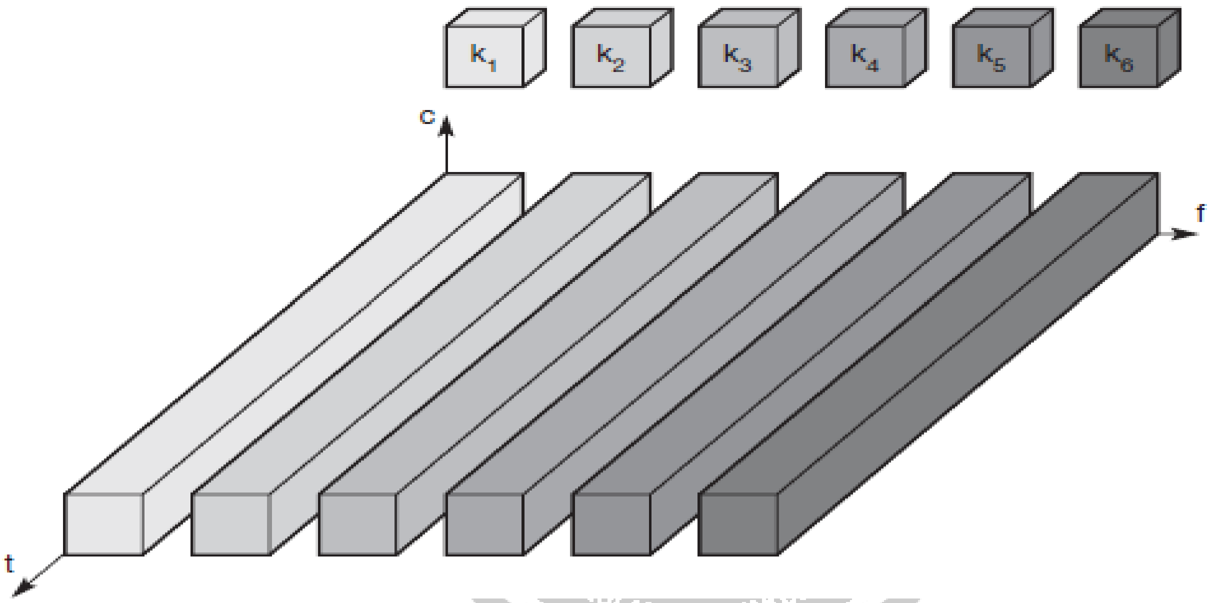
Again, **guard spaces** are needed to avoid frequency band overlapping (also called **adjacent channel interference**).

This scheme is used for **radio stations within the same region**, where each radio station has its own frequency. This very simple multiplexing scheme does not need complex coordination between sender and receiver: the receiver only has to tune in to the specific sender.

- **Advantages**
  - **No dynamic coordination necessary**
  - **Works also for analog signal**

Disadvantages:

- ✓ While radio stations broadcast 24 hours a day, mobile communication typically takes place for only a few minutes at a time. Assigning a separate frequency for each possible communication scenario would be a **tremendous waste of (scarce) frequency resources**.
- ✓ Additionally, **the fixed assignment of a frequency to a sender makes the scheme very inflexible and limits the number of senders.**



C. Time division multiplexing:

Here a channel ki is given the **whole bandwidth for a certain amount of time**, i.e., all senders use the same frequency but at different points in time.

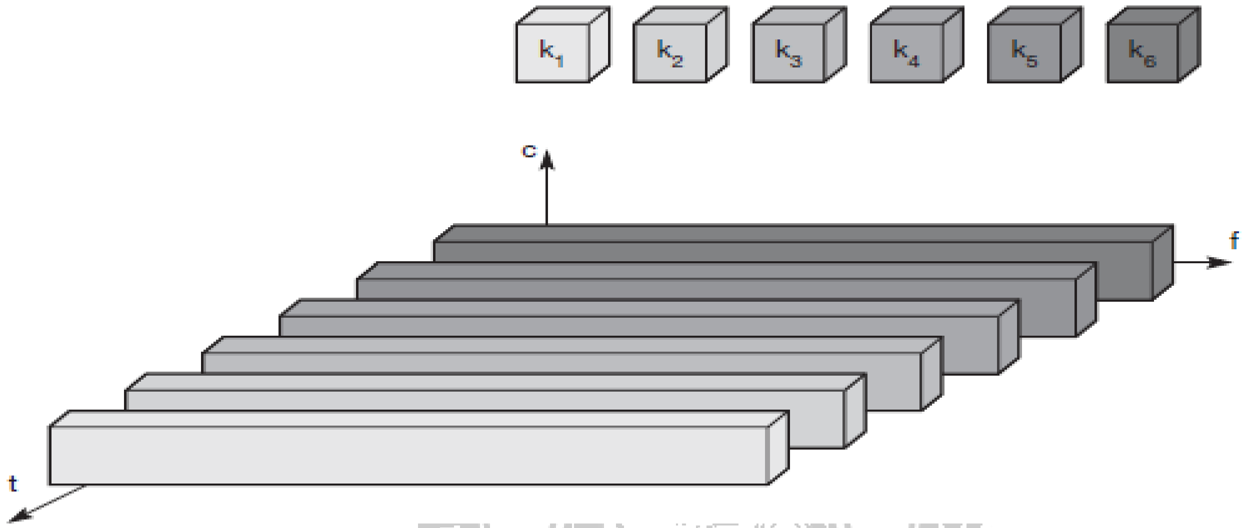
Again, **guard spaces**, which now represent time gaps, have to separate the different periods when the senders use the medium. In our highway example, this would refer to the gap between two cars.

If two transmissions overlap in time, this is called **co-channel interference**. (In the highway example, interference between two cars results in an accident.)

To avoid this type of interference, **precise synchronization between different senders** is necessary.

Advantages:

- Only one carrier in the medium at any time
- Throughput high even for many users
- **Disadvantages**
- Precise clock synchronization necessary



Frequency and time division multiplexing

Frequency and time division multiplexing can be combined, i.e., a channel

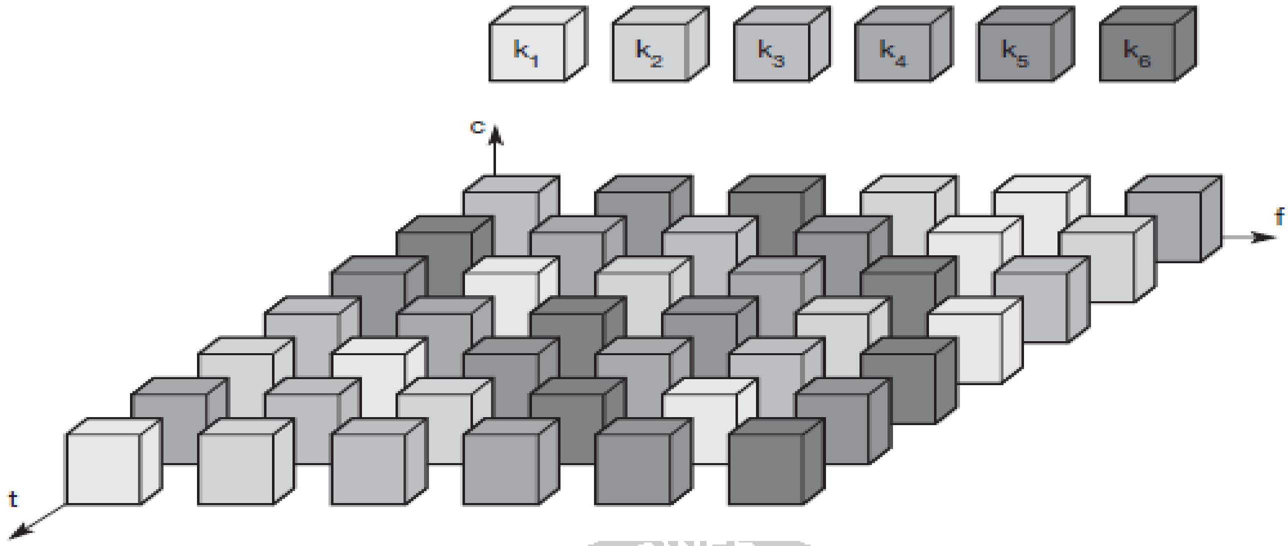
- A channel gets a certain frequency band for a certain amount of time

. **Now guard spaces are needed** both in the **time and in the frequency dimension**.

- Example: **GSM**
- **Advantages**
  - Better protection against tapping
  - Protection against frequency selective interference

Disadvantages

Precise clock synchronization necessary



D. *Code division multiplexing:*

- Below figure shows how all channels ki use the same frequency at the same time for transmission.
- **Separation is now achieved by assigning each channel its own 'code'**,
- **Guard spaces are realized by using codes with the necessary 'distance' in code space, e.g., orthogonal codes.**
- **Implemented using spread spectrum technology**

- The typical everyday example of CDM is a party with many participants from different countries around the world who establish communication channels, i.e., they talk to each other, using the same frequency range (approx. 300–6000 Hz depending on a person's voice) at the same time. If everybody speaks the same language, SDM is needed to be able to communicate (i.e., standing in groups, talking with limited transmit power).

- But as soon as another code, i.e., another language, is used, one can tune in to this language and clearly separate communication in this language from all the other languages. (The other languages appear as background noise.)

- This explains why CDM has **built-in security**: if the language is unknown, the signals can still be received, but they are useless. By using a secret code (or language), a secure channel can be established in a 'hostile' environment. (At parties this may cause some confusion.). Guard spaces are also of importance in this illustrative example. Using, e.g., Swedish and Norwegian does not really work; the languages are too close. But Swedish and Finnish are 'orthogonal' enough to separate the communication channels.

Advantages

- Bandwidth efficient
- No coordination and synchronization necessary
- Good protection against interference and tapping

Disadvantages

Precise power control required

More complex signal regeneration