Fixed Assignment Schemes

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Fixed Assignment Schemes

- Classified into

1. Space Division Multiple Access (SDMA)
2. Frequency Division Multiple Access(FDMA)
3. Time Division Multiple Access (TDMA)
4. Code Division Multiple Access (CDMA)

SDMA

- ace Division Multiple Access (SDMA) is used for allocating a separated space users in wireless networks.
- ypical application involves assigning an optimal base station to a mobile one user.
- e mobile phone may receive several base stations with different quality.
- MAC algorithm could now decide which base station is best, taking into count which frequencies (FDM), time slots (TDM) or code (CDM) are still ailable (depending on the technology).
- pically, SDMA is never used in isolation but always in combination with one or ore other schemes.

SDMA…..

- The SDMA algorithm is formed by cells and sectorized antennas which constitute the infrastructure implementing **space division multiplexing (SDM)**
- A new application of SDMA comes up together with beam-forming antenna arrays
- Single users are separated in space by individual beams. This can improve the overall capacity of a cell (e.g., measured in bit/s/m2 or voice calls/m2) tremendously.

Frequency Division Multiple Access (FDMA)

- **Frequency division multiple access (FDMA)** comprises all algorithms allocating frequencies to transmission channels according to the **frequency division multiplexing (FDM)** scheme
- Allocation can either be fixed (as for radio stations or the general planning and regulation of frequencies) or dynamic (i.e., demand driven).

Pure FDMA

- Channels can be assigned to the same frequency at all times, i.e., pure FDMA

FDMA combined with TDMA

- change frequencies according to a certain pattern

Frequency Division Multiple Access (FDMA)

Frequency Hopping

- latter example is the common practice for many wireless systems to circumvent narrowband interference at certain frequencies, known as frequency hopping.
- Sender and receiver have to agree on a hopping pattern, otherwise the receiver could not tune to the right frequency

Duplex channel

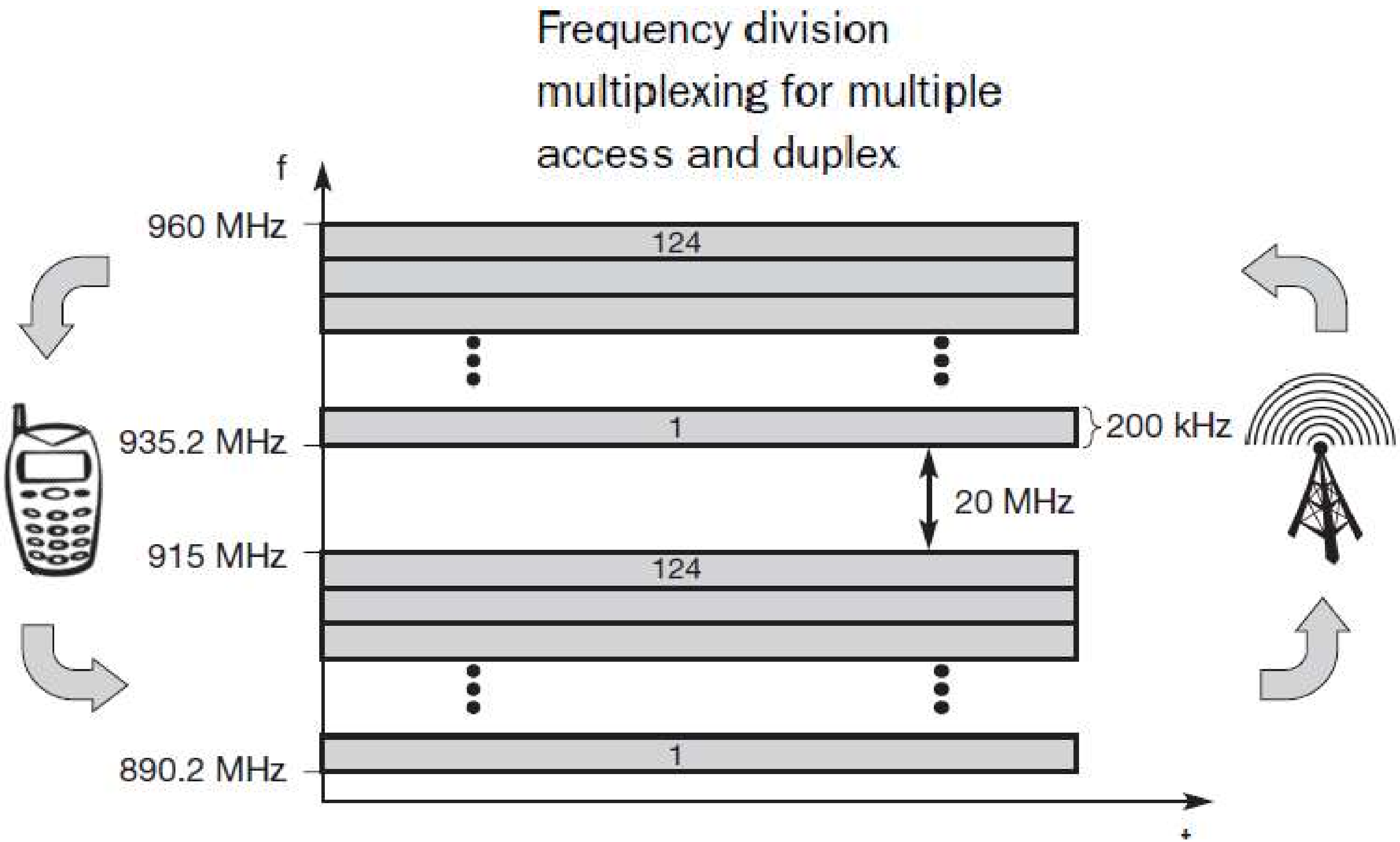
- FDM is often used for simultaneous access to the medium by base station and mobile station in cellular networks.
- Here the two partners typically establish a **duplex channel**, i.e., a channel that allows for simultaneous transmission in both directions.

Frequency Division Multiple Access (FDMA)

Frequency division duplex (FDD)

- The two directions, mobile station to base station and vice versa are now separated using different frequencies. This scheme is then called **frequency division duplex (FDD)**.
- Again, both partners have to know the frequencies in advance; they cannot just listen into the medium.
- The two frequencies are also known as **uplink and Downlink**

equency Division Multiple Access (FDMA)



equency Division Multiple Access (FDMA)

Uplink Frequency (For Transmission)

- from mobile station to base station or from ground control to satellite
- All uplinks use the band between 890.2 and 915 MHz

Downlink Frequency (Receiving information)

- from base station to mobile station or from satellite to ground control
- all downlinks use 935.2 to 960 MHz

equency Division Multiple Access (FDMA)

Allocation of uplink and downlink Frequency

- According to FDMA, the base station, shown on the right side, allocates a certain frequency for up- and downlink to establish a duplex channel with a mobile phone.
- Up- and downlink have a fixed relation
- If the uplink frequency is $f_u = 890\text{ MHz} + n \cdot 0.2\text{ MHz}$, the downlink frequency is $f_d = f_u + 45\text{ MHz}$, i.e., $f_d = 935\text{ MHz} + n \cdot 0.2\text{ MHz}$ for a certain channel n.
- The base station selects the channel. Each channel (uplink and downlink) has a bandwidth of 200 kHz.
- This illustrates the use of FDM for multiple access (124 channels per direction are available at 900 MHz) and duplex according to a predetermined scheme.

equency Division Multiple Access (FDMA)

Disadvantages of FDMA

- When a call is underway, no other user would be allocated the same frequency band to make a call.
- Unused transmission time in a frequency band that occurs when the allocated caller pauses between transmissions.
- Or when no user is allocated a band, goes idle and is wasted
- FDMA not achieve a high channel utilization.

me Division Multiple Access (TDMA)

- Compared to FDMA, time division multiple access (TDMA) offers a much more flexible scheme, which comprises all technologies that allocate certain time slots for communication, i.e., controlling TDM
- Now tuning in to a certain frequency is not necessary, i.e., the receiver can stay at the same frequency the whole time.
- Using only one frequency, and thus very simple receivers and transmitters, many different algorithms exist to control medium access.

Fixed TDM

- The simplest algorithm for using TDM is allocating time slots for channels in a fixed pattern. This results in a fixed bandwidth and is the typical solution for wireless phone systems.
- MAC is quite simple, as the only crucial factor is accessing the reserved time slot at the right moment. If this synchronization is assured, each mobile station knows its turn and no interference will happen.

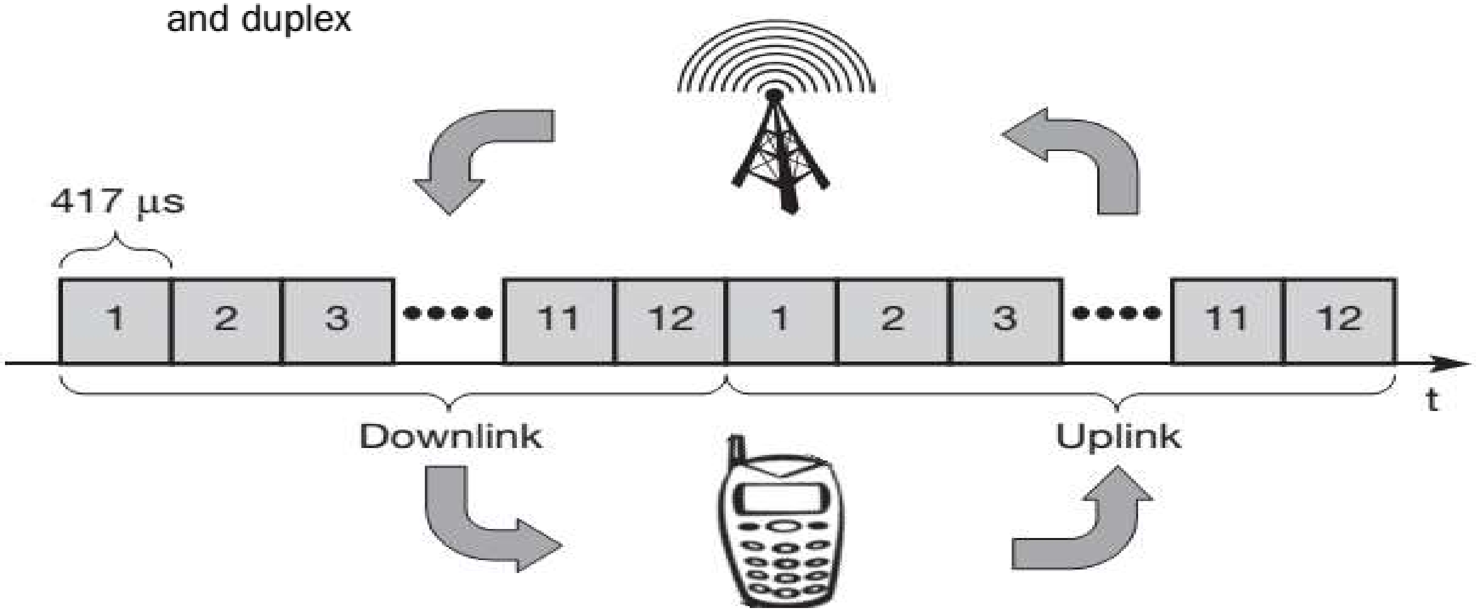
me Division Multiple Access (TDMA)

Time Division Duplex (TDD)

- fixed TDM patterns are used to implement multiple access and a duplex channel between a base station and mobile station.
- Assigning different slots for uplink and downlink using the same frequency is called time division duplex (TDD).
- As shown in the figure, the base station uses one out of 12 slots for the downlink, whereas the mobile station uses one out of 12 different slots for the uplink.
- Uplink and downlink are separated in time.
- Up to 12 different mobile stations can use the same frequency without interference using this scheme. Each connection is allotted its own up- and downlink pair.

me Division Multiple Access (TDMA)

Time division
multiplexing for
multiple access
and duplex



me Division Multiple Access (TDMA)

• In the example below, which is the standard case for the DECT cordless phone system, the pattern is repeated every 10 ms, i.e., each slot has a duration of 417 μs.

•This repetition guarantees access to the medium every 10 ms, independent of any other connections.

me Division Multiple Access (TDMA)

Disadvantages of TDMA

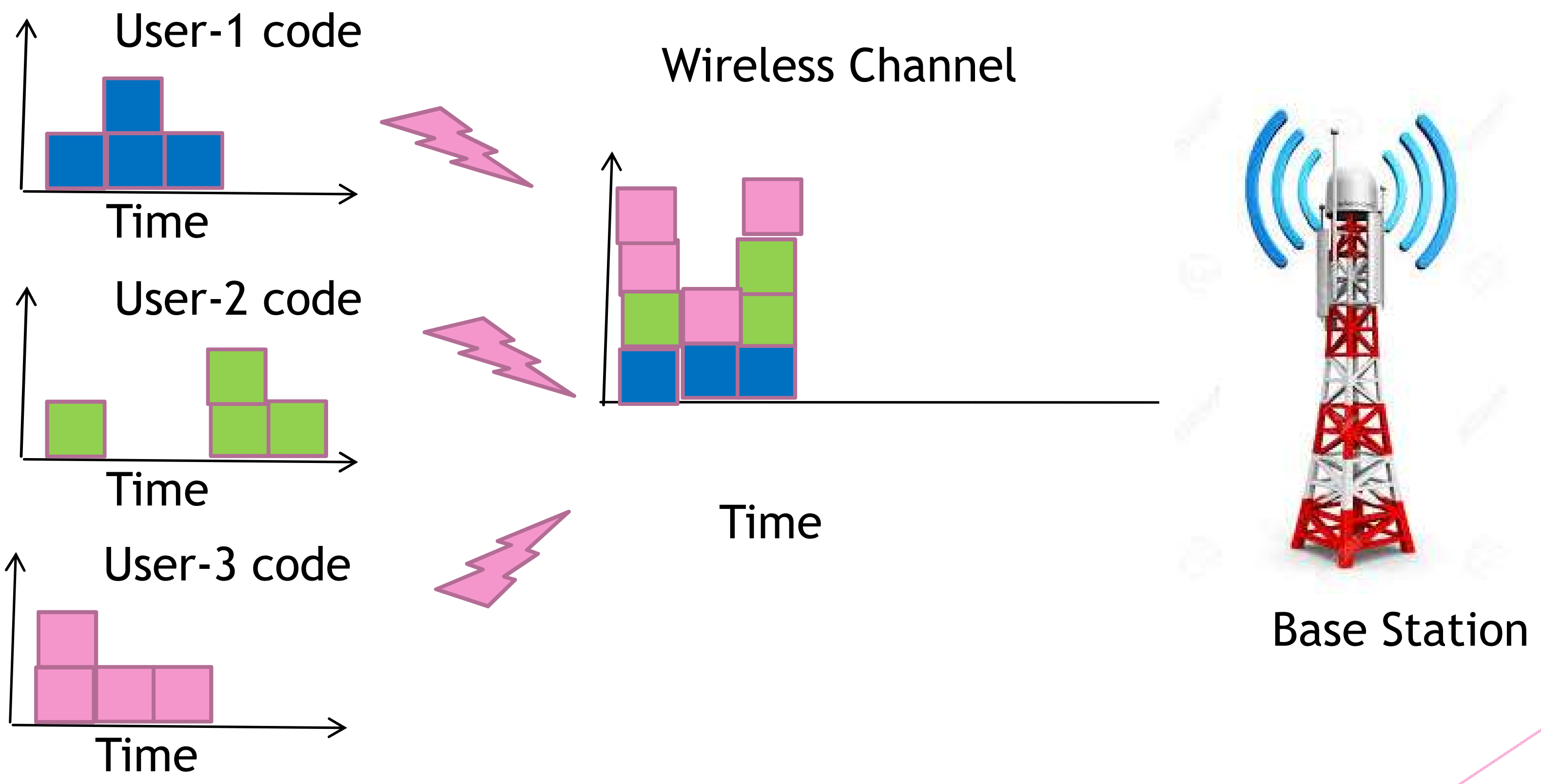
- Unused Time slots go idle , leading to low channel Utilization.

de Division Multiple Access (CDMA)

- In CDMA , Multiple Users are allotted different codes that consists of sequences of 0’s and 1’s to access the same channel.
- As shown in fig , a special coding scheme is used that allows ignal from multiple users to be multiplexed over the same physical hannel.
- As shown in fig, three different users who have been assigned eparate codes are multiplexed on the same physical channel.
- In CDMA multiple users use the same frequency at the same time nd no time scheduling algorithm is used.
- All the senders send the signal simultaneously through a common nedium

ode Division Multiple Access (CDMA)

- Schematic diagram of code division multiple access.



ode Division Multiple Access (CDMA)

Pseudo-Noise Code Sequence

- _The bandwidth of this medium is much larger than the space that would be allocated to each packet transmission during FDMA and the signals are distinguished from each other by means of special coding scheme.
- This coding is done with the help of a frequency spreading code known as the m-bit pseudo-noise code sequence
- Using m bits 2^m-1 different codes are obtained. From these codes, each user will use only one code.

ode Division Multiple Access (CDMA)

How to distinguish transmission from different nodes?

- A code for a user should be orthogonal (i.e non-interfering) to the codes assigned to the other nodes.
- orthogonal means the vector inner product is zero.
- good autocorrelation uses the bipolar notation where a code sequence of binary 0 is represented as -1 and binary 1 is represented as +1.
- On the receiving end, only the same PN sequence is able to demodulate the signal successfully convert the input data.

de Division Multiple Access (CDMA)

How to distinguish transmission from different nodes?

- Example

1)Two vectors are called orthogonal if their inner product is 0, as is the case for the two vectors (2, 5, 0) and (0, 0, 17):

$$(2, 5, 0)*(0, 0, 17) = 0 + 0 + 0 = 0.$$

2) Vectors like (3, -2, 4) and (-2, 3, 3) are orthogonal:

$$(3, -2, 4)*(-2, 3, 3) = -6 - 6 + 12 = 0.$$

ode Division Multiple Access (CDMA)

- basic function of CDMA- Example
- Two senders, A and B, want to send data. CDMA assigns the following unique and orthogonal key sequences:
  - key Ak = 010011 for sender A,
  - key BK = 110101 for sender B.
  - Sender A wants to send the bit Ad = 1, sender B sends Bd = 0.
- To illustrate this example, let us assume that we code a binary 0 as –1, a binary 1 as +1. We can then apply the standard addition and multiplication rules.
- Both senders spread their signal using their key as chipping sequence (the term 'spreading' here refers to the simple multiplication of the data bit with the whole chipping sequence).
- In reality, parts of a much longer chipping sequence are applied to single bits for spreading.
- Sender A then sends the signal

As = Ad*Ak = +1*(-1, +1, -1, -1, +1, +1) = (-1, +1, -1, -1, +1, +1).

- Sender B does the same with its data to spread the signal with the code:

Bs = Bd*Bk = -1*(+1, +1, -1, +1, -1, +1) = (-1, -1, +1, -1, +1, -1).

ode Division Multiple Access (CDMA)

Both signals are then transmitted at the same time using the same frequency, o, the signals superimpose in space

the following signal C is received at a receiver:

C = As + Bs = (-2, 0, 0, -2, +2, 0).

The receiver now wants to receive data from sender A and, therefore, unes in to the code of A, i.e., applies A's code for despreading:

A k = (-2, 0, 0, -2, +2, 0)(-1, +1, -1, -1, +1, +1) = 2 + 0 + 0 + 2 + 2 + 0 = 6.

s the result is much larger than 0, the receiver detects a binary 1.

Tuning in to sender B, i.e., applying B's code gives

C*Bk = (-2, 0, 0, -2, +2, 0)*(+1, +1, -1, +1, -1, +1) = -2 + 0 + 0 - 2 - 2 + 0 = -6.

he result is negative, so 0 has been detected.