TSKS03 Wireless Systems

Solutions for the exam 2013-08-21

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1
We start with the problem.

This has primarily to do with the uplink. Ideally, subchannels used by different users should be orthogonal. Each subchannel would then be possible to filter out individually. In that case, different users would not interfere with each other. In practice, due to oscillator uncertainty and timing uncertainty, and sometimes also design choices, the subchannels are not completely orthogonal, and thus users do cause interference to each other.

The other part of the problem is called the near-far effect, and is due to the fact that different users experience different channels. This is to a large extent due to different distances between the different users on one hand and the basestation on the other, and that is the reason for the name. It is also due to multi-path propagation and shadowing. If all users use the same sender power, then since they experience different channels, the corresponding received powers will be different. Since the channels are not completely orthogonal, users with good channels will cause unacceptable interference to users with bad channels.

The solution to the problem is power control, which aims at obtaining the same received power from all users at the basestation, by adjusting each user's sender power. This is done in the following way. The basestation estimates the received power for each user, and individually orders each user to increase or decrease its sender power.

The result is twofold: Each received user signal experiences approximately equally much interference from other users. Also, each mobile phone uses approximately as little power as needed for the situation, thus increasing the battery life of the phone compared to not using power control.

2
In FSK, each signal has its own frequency. The input to a modulator consisting of a VCO (Voltage-Controlled Oscillator) is then constant in each signal interval, and changes from one signal interval to the next occurs momentarily, i.e. as steps, which makes the modulaton form relatively wide-band, in terms of spectral roll-off. In GFSK, the transition between frequencies is gradual, due to a Gaussian filter that is placed between the input to the modulator and the VCO. This gradual transition makes the spectral rolloff much steeper (essentially infinite), resulting in a more narrow-band signal.

3
Different users experience different, essentially independent, channels. The task of the scheduler is to assign channel resources to the users, and also to decide what rate to use in these resources. In OFDM, it is natural to view carrier frequencies and time intervals as a way to split up the channel in resource blocks in time and frequency. These blocks are the channel resouces that the scheduler assigns to users. The scheduler uses channel estimations as basis for its decisions, primarily for assign each channel block to a user that has a good channel for that particular block. This aims at maximizing the total throughput of the system.

4
Access methods are methods to share a common channel between simultaineously active users. If we have a channel with bandwidth B, then each time interval of duration T contains approximately $2BT$ dimensions. Access methods are therefore supposed to share those $2BT$ dimensions between the users.

Another problem that is related to access methods is frequency selective fading, which is a reality on mobile radio channels. Different access methods have different sensitivity for this type of fading, and the choice of access method is made to avoid this impact, or rather to spread this impact equally over all users.

5
The dominating disturbance in radio receivers is thermal noise. It is caused by random movements among electrons, and a good model for this noise is white Gaussian noise.

When demodulating digital modulated signals this noise causes a multi-dimensional jointly Gaussian variable consisting of independent components that is added to the sent signal point. This in turn - together with equally probable signals - is the reason that the received signal point should be interpreted as the closest signal point in Euclidean sense, which minimizes the error probability given the power spectral density of the noise.

It is the combination of noise and fading that makes reception of radio signals a challenge. Without noise, we would be able to distinguish signal points regardless of the fading. Without fading, we would not need to estimate the channel in the receiver.

6

The grading of this task is based on two points per technique.

Cell splitting
: The SIR (Signal-to-Interference Ratio) of co-channel interference is approximately proportional to the ratio d_2^2/d_1^2, where d_1 is the distance to the intended basestation from a mobile, and where d_2 is the distance to the closest other basestation using the same subchannel. If we reduce the size of the cells, this ratio will be on average the same, and we can keep the number of channels per cell. Thus, we increase the number of cells per unit coverage area and also the capacity in terms of channels per unit coverage area.

Sectoring
: Consider a basestation with an omnidirectional antenna. Then the cell will be roughly circular symmetric. By using directional base-station antennas, we can split this cell into sectors, each effectively working as a cell of its own. The available channels are then split among those sectors. This in itself does not increase the capacity. However, this approach reduces the co-channel interference and thus allows for tighter co-channel reuse.

7

In cellular systems, the users are allowed to move. Radio signals get weaker (on average) the further away you are from the base station, and the signal strength also varies due to multi-path transmission and shadowing. Therefore, staying connected to the same base station all the time can result in bad communication quality and ultimately to lost communication. A user may very well move from a point where the communication quality is best through one base station to a point where the communication quality is best through another base station. In that event, the system can transfer the communication from the first to the second base station. This process is called handover or handoff.

The basestations often use directional antennas to separate the surrounding area into separate sectors. Then handover is also used when a user moves from one sector to another. Depending on the load of the system, handover can also be used to move users from a crowded cell to a neighbouring less crowded cell in order to facilitate more users, even though a user might not get the best possible channel.

Hard handover means that a user is only connected to one base station at a time. After negotiations between the user equipment and the system, the communication switches from one base station to another or from one sector to another. This is also known as break-before-make.

In soft handover, on the other hand, the handover is gradual. When the communication channel to two or more base stations (or sectors) are approximately equally good, then communication is done through all those base stations (or sectors). This is also known as make-before-break.

8

This is most certainly not the only possible answer to this question. There are definitely more technical details where the two systems differ. The grading is based on one point per technical detail.

Access method
: Pure GSM uses a mix of TDMA and FDMA, and the standard also allows for frequency hopping. Pure UMTS uses DS-CDMA.

Modulation method
: Pure GSM uses binary GMSK. Pure UMTS uses 4-PSK.

Handover
: Pure GSM uses hard handover. Pure UMTS uses soft handover.

Bandwidth
: Pure GSM uses subchannels of roughly 200 kHz bandwidth. Pure UMTS uses at least 5 MHz bandwidth.

Data-rate
: Pure GSM provides only 9.6 kb/s. Pure UMTS provides at least 384 kb/s.

Duplexing methods
: Pure GSM uses FDD. Pure UMTS allows for both FDD and TDD.

9

You do not need to explain your answers in this task. All that is needed is a true or a false. However, a short explanation or comment is given here for some claims.

a. **True**. Packing data is the primary purpose of source coding.

b. **True**.

c. **False**. Kasami sequencies are pseudo-nose sequencies, usually used as spreading sequencies.

d. **False**. Gold sequencies are generated using two binary linear feedback shift registers, based on two different primitive polynomials.

e. **False**. Hard handover is quite the opposite. You communicate through one base station at a time, and the handover is done by simply switching from one base station to another.

f. **True**. M is for minimum as in small bandwidth.