Exercises for the lecture

Collaborative transmission in wireless sensor networks

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1 Communication in wireless networks

1.1 CDMA spreading

In CDMA systems we distinguish between different mobiles by assigning orthogonal spreading codes ($c_i \in \{0,1\}^k$; $k \in \mathbb{N}$) to mobile i. Instead of transmitting d_i the combined sequence $d_{r,i} = XOR(c_i^{|d_i|}, d_{|c_i|,i})$ is transmitted. $d_{|c_i|,i}$ is obtained from d_i by repeating every symbol in d_i exactly $|c_i|$ times (Example: $d_i = 01$, $|c_i| = 2 \rightarrow d_i^{|c_i|} = 0011$). c_i^l is obtained by concatenating l times c_i. At the Receiver the received signal $d_{r,i}$ is again combined (XOR) with $c_i^{\left|\frac{d_{r,i}}{|c_i|}\right|} = c_i^{|d_i|}$.

a) What are the benefits and drawbacks of spreading the signal?

b) Given a data sequence $d_1 = 0101$ ($d_2 = 1010, d_3 = 1001, d_4 = 1111$) and a spreading code $c_1 = 1111$ ($c_2 = 1100, c_3 = 1010, c_4 = 1001$) calculate the spreaded signal.

c) Visualise your results. Additionally add the despreaded sequences to your figure.

d) In order to be able to use spreading codes of different length simultaneously OVSF (orthogonal variable spreading factor) is used. OVSF guarantees that spreading codes of different length remain orthogonal. Starting with a root spreading code $c_{i,j} \in \{0,1\}^i$; $i,j \in \mathbb{N}$ we create new spreading codes $c_{2i,2j-1} = (c_{i,j}c_{i,j})$ and $c_{2i,2j} = (c_{i,j}\overline{c_{i,j}})$. Where $\overline{x}$ is the binary complement of x. Starting with $c_{1,1} = (1)$ create the complete tree of spreading codes up to a length of 16.

1.2 Calculating with dB

a) At the receiver a power level of $100\mu V$ is measured. What is the power level if the signal is weakened by 40 dB?

b) A base station is transmitting at $5W$. By how many dB is the power increased if the base station transmits at $20W$?

c) A base station is transmitting at 40 dBm. The signal experiences a cable damping of 4 dB until it reaches the antenna. If the antenna gain is 2,5 dBi, of what amount is the effective isotropically-radiated power (EIRP) in dBm and in Watt?

1.3 Multipath propagation

Assume a mobile device to be 20km far off it's communication partner.

a) Of what amount is the time delay between the sending of the signal by the mobile device and the receiving of the signal by the communication partner?

b) Assume a reflecting obstacle behind the communication partner (for example a mountain). Calculate the time delay between the sending of the signal by the mobile station and the receiving of the reflected signal by the base station. The distance between the base station and the obstacle is 100m.

1.4 Pathloss for different wireless technologies

Consider a Jennic sensor node with 3dBm transmission power (antenna gain 0dBi), a mobile station that transmits at 2W in GSM (antenna gain 0dBi), a GSM base station that transmits at 10W (antenna gain 3dBi), a DAB (digital audio broadcasting) transmitter with 1 kW EIRP (230 MHz), a DVB-T (digital video broadcast) transmitter with an EIRP of 10kW (800 MHz). Furthermore, consider a Bluetooth transmitter with 2.5 mW EIRP (2.4GHz) and a Wlan transmitter with 100mW EIRP (2.4GHz). Calculate the signal strength at a receiver at a distance of

a) 10cm

b) 1m

c) 1km

Assume that the receiver has an antenna gain of 0dBi. Note: Antenna gain of a DVB-T roof-mounted antenna with 800MHz: 12dB. Indoor antenna: -2 to 0 dB)