Assignments PhD interview Super GPS project

Subjects related to Wireless Communication: propagation and modulation

Assignment 1.

On the 17th floor of the EEMCS building, a WiFi system is operated to provide wireless internet access to students and staff members of the CAS group. At the end of the floor, a single access point is mounted to the ceiling, as shown in figure 1. The access point is active on IEEE 802.11 channel 1 (2412 MHz) and uses a high gain directional antenna (gain G_{ant_ap} = 12 dBi) which focuses the transmitted energy in azimuth as well as in elevation to cover the whole floor and in particular the rooms and laboratories.
The transmit power is P_t = +20 dBm and the minimum required signal level at the receiver for good operation is $P_{r,\min}$ = -84 dBm. The antenna gain of a WLAN device integrated in a laptop can be assumed as G_{ant_mob} = 2 dBi.

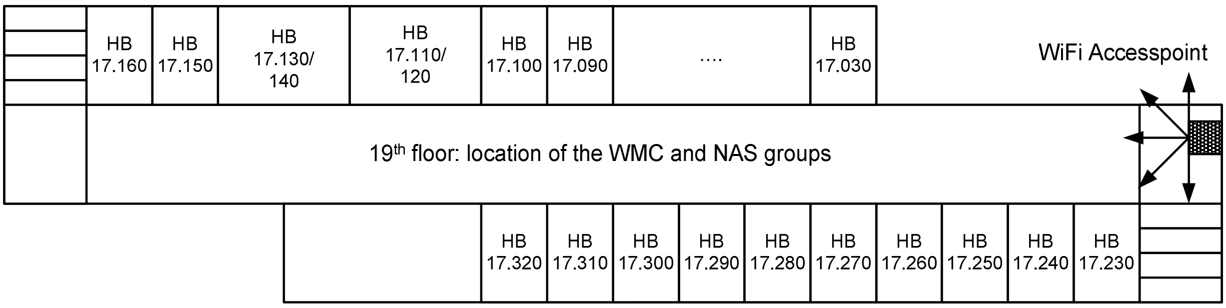

Figure 1: Overview of the 17th floor of the EEMCS building.

The radio propagation of this environment is characterized by a path-loss exponent γ = 4.5, and log-normal shadow fading with a standard deviation of σ_s = 7 dB, and multipath fading. Take the reference distance $d_0 = 1.5$ m and assume the path loss equal to the free space loss at this distance.

a) Determine the expected value of the received local-mean signal power $P_{r,lm}$ in room HB17.320, at a distance of 45 m from the access point.

b) Determine the probability that the local-mean received signal power $P_{r,lm}$ is less than $P_{r,\min}$ in room HB17.160, at a distance of 75 m from the access point.

In the large laboratory room HB17.130/140, the amplitude fluctuation of the received signal power P_r due to small scale fading is Rayleigh distributed and the local mean value of the received signal power is $P_{r,lm}$ = -82 dBm.

c) Calculate the outage probability in this laboratory room.

In order to improve the reception performance the application of antenna diversity is investigated. Since our laptop is equipped with a single antenna, it is moved to different locations within laboratory room HB17.130/140.

d) Determine the probability that we find at least one location with sufficient signal strength when we try at four randomly selected locations.

e) 1. Explain the principle of operation of Maximal Ratio Combining (use no more than 50 words),
2. Clearly indicate and motivate what you expect for the obtained SNR in case Maximal Ratio Combining is used and in case Selection Diversity is used, with the same number of diversity branches and further under identical conditions (use no more than 50 words).

Assignment 2

A wireless system operating in the 2.4 GHz license free band uses 16-QAM modulation in combination with DS-SS with a chip rate of 11 MHz. The data rate is 2 Mbit/s and the signal transmitted at carrier frequency $f_c = 2442$ MHz is received with a power of -60 dBm.
The single sided power spectral density for a modulated data signal with rectangular pulses with pulse duration *T* and signal power *P*, is given by:

$$S(f) = PT\left(\frac{\sin \pi (f - f_c)T}{\pi (f - f_c)T}\right)^2 .$$

a) Calculate the received power spectral density (in dBm/Hz) at the carrier frequency of:
- the 16-QAM modulated signal if no DS-SS is used,
- the 16-QAM modulated signal with DS-SS,

and determine the processing gain of the DS-SS signal.

b) Explain why/how DS-SS creates robustness against narrowband interference.

In WLAN 802.11, a fixed spreading sequence of eleven (11) symbols is used. This so-called Barker sequence consists of the following symbols:

+1, -1, +1, +1, -1, +1, +1, +1, -1, -1, -1

c) Show and motivate whether the Barker sequence has good auto-correlation properties.

In the IEEE 802.11b standard, the data rate for DS-SS is increased by applying Complementary Code Keying (CCK).

d) Explain the principle behind CCK.