Alpen-Adria-Universität Klagenfurt
Mobile Systems Group



# GROUP PROJECT: PATH LOSS AND SHADOWING

In mobile communication systems, radio waves transmitted over the air suffer from path loss and shadowing. The goal of this project is to investigate these two large-scale fading phenomena using computer-based simulations.

## Modeling Assumptions

The average loss in the downlink, i.e. from the base station to the mobile device, is modeled using the COST231-Hata model. For a transmission frequency $f$, the average loss experienced by a mobile device in a medium-sized city is

$$L^{(\mathrm{dB})} = 45.5 + 35.46 \log \frac{f}{\mathrm{MHz}} - \left(1.1 \log \frac{f}{\mathrm{MHz}} - 0.7\right) \frac{h_r}{\mathrm{m}} \quad (1)$$

$$+ \left(44.9 - 6.55 \log \frac{h_t}{\mathrm{m}}\right) \log \frac{d}{\mathrm{km}} - 13.82 \log \frac{h_t}{\mathrm{m}} \quad (2)$$

The term $d$ denotes the distance between the base station and the mobile device. The terms $h_t$ and $h_r$ denote the physical height of the transmitting base station and the receiving mobile device, respectively. The model is valid for $1.5\,\mathrm{GHz} < f < 2\,\mathrm{GHz}$, $30\,\mathrm{m} < h_t < 200\,\mathrm{m}$, $1\,\mathrm{m} < h_r < 10\,\mathrm{m}$, and $1\,\mathrm{km} < d < 20\,\mathrm{km}$.

Shadowing is caused by obstacles in the environment and results in random fluctuations of the received power around its average value (fading). These fluctuations are described by a zero-mean Gaussian probability density function (with power values in dB and variance $\sigma^2$).

## Project Task

Your task is to study, by means of computer simulation, the following question for a mobile radio technology of your choice, in the above described radio environment: What is the probability $p$ that a mobile device has a wireless link to the base station when being located at a certain distance $d$ from this base station?

a) Decide on a wireless technology of your choice. Find in its technical specification the values for (a) the maximum transmit power $p_t$ of the base station and (b) the minimum reception power $p_r^{(min)}$ required to establish a wireless link. The latter power is called the "receiver sensitivity." Moreover, determine a typical transmission frequency $f$.

b) Write a small computer program in a language of your choice, which implements the above propagation models. Input: Variables of the scenario $(d, \sigma)$. Output: Link probability $p$.

c) Study $p$ as a function of the distance $d$ and $\sigma$ for all other parameters fixed to a reasonable value. Visualize the result in plots.

As in all simulation-based studies, the statistical confidence of the simulation results is of high importance. For a given set of input parameters, the link probability should be estimated from a large set of random samples.

Each group is expected to summarize the work in a set of 5 to 8 slides describing the approach and main results. The mandatory content is as follows:

- List of active participants and their contributions
- Simulation and programing approach
- Plot of the link probability $p$ as a function of the distance $d$ for suitable other parameters
- Additional plots showing the impact of $\sigma$

Selected project groups will be asked to present their work in class (10-minute presentation).

## Hints

- Consider the frequency range of the COST model when choosing your technology.
- A Gaussian distributed random number can be obtained from a uniform random number generator using the Box-Müller transform.
- Also consider the special case without shadow fading. Plotting $L$ you will get a rough estimate whether your results can be correct or not.
- Although you are free to choose your programming language, a good choice might be `octave`. It is a high-level language for numerical computations and graphical output with similar basic functionality as Matlab. You can get it from
  - http://sourceforge.net/project/showfiles.php?group_id=2888.

  The official Web sites are
  - http://www.octave.org
  - http://octave.sourceforge.net

  If you need help installing Octave, try:
  - http://www.tu-harburg.de/ matjz/work/octave/
- Split the work among the group members!

## Submission

Please send your slides to Professor Bettstetter. Use filename "project-path-loss-shadowing-group0x.ppt" or "project-path-loss-shadowing-group0x.pdf" and the subject "[MWS1] Project 1, group0x".