Technische Universität Braunschweig

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Fundamentals of Mobile Radio Communications

Exercise 2: Cellular Concept in Mobile Communication

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1 Cellular Concept - Basics

Remark: For simplicity reasons, cells are assumed to be hexagonal.

1.1 What is the cellular concept?

Instead of using one base station to cover the whole coverage area of a mobile network operator, the area is split into smaller subsections called "cells". This enables the use of antennas with lower heights and the spatial repetition of frequencies.

Cell type	Cell radius (typical)	Typical usage
macrocell	2 km to 30 km	Rural areas
microcell	200 m to 2000 m	(Sub)urban areas
picocell	50 m to 200 m	Dense urban areas
femtocell	0 m to 50 m	High density events (e.g. sports events)

Table 1: Typical cell types

1.2 What challenges need to be faced when introducing cells in a mobile radio network?

Since resources (frequencies) are limited and therefore need to be reused, cellular communication is facing the problem of inter-cell interference.
Also, users are moving from one cell to another, so **handovers** need to be carried out to enable seamless connectivity. Challenges are signal fluctuations, interference, and high-speed mobility. Poorly configured thresholds can lead to unnecessary handovers (ping-pong effect) or failed transitions, causing dropped connections.

1.3 Why not cover the largest possible area with one base station, as is done with broadcasting?

Possible problems:

- Uplink: UE needs a much higher transmission power
- Channel is a shared medium: Limited number of frequency bands, resource allocation only for small number of UEs simultaneously

Example calculations in GSM:

2 Cellular Concept - Configuration of cell parameters

In a planned GSM mobile radio network, a voice service is provided and for optimal Quality of Service (QoS), a maximum block error rate (BLER) of 0.1 is needed (fig. 1). To ensure that the transmission power used is not too high, the cells in the network should have a cell radius R of 1 km.

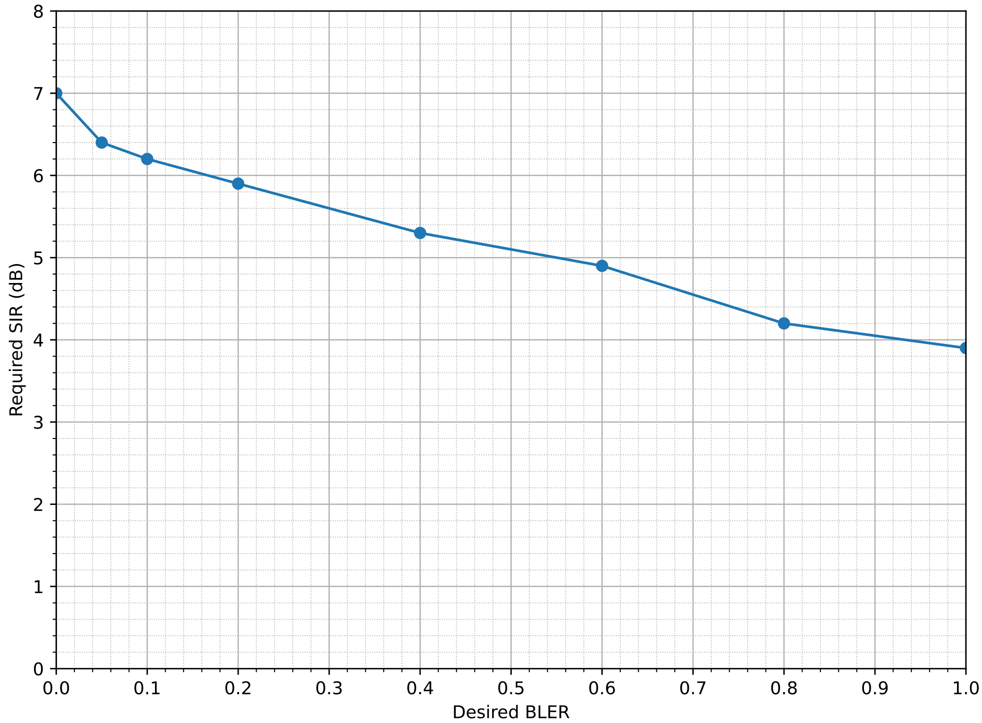

Figure 1: Relationship between BLER and SIR

2.1 What is the minimum frequency reuse distance that needs to be selected so that an MS can still be served at the cell edge? For the calculations, assume a propagation coefficient γ of 3.

2.2 What is a cluster (in general) and how big should the cluster size k be (in our example)?

A cluster is a group of cells which makes use of all available resources (frequencies). The frequencies are reused in neighbouring clusters, respecting the frequency reuse distance. The following relationship applies:

$$D = R \cdot \sqrt{3 \cdot k} \quad \Leftrightarrow \quad k = \frac{1}{3}\left(\frac{D}{R}\right)^2$$

In our example ($R = 1\,\text{km}$, $D = ?$):

2.3 What does a cluster size of $k = 1$ mean? When is this case used?

For cluster size $k = 1$, all cells use the same frequency.

2.4 What would be the effect of additional sectorisation? Could the cluster size be reduced by using 3-sector cells?

When combining both equations from ex. 2.1 and 2.2, we get:

$$SIR = \frac{1}{6}(3k)^{\gamma/2}$$

For a number of n sectors, this relationship changes to:

$$SIR = \frac{n}{6}(3k)^{\gamma/2} \quad \Leftrightarrow \quad k = \frac{1}{3}\left(\frac{6}{n}SIR\right)^{2/\gamma}$$