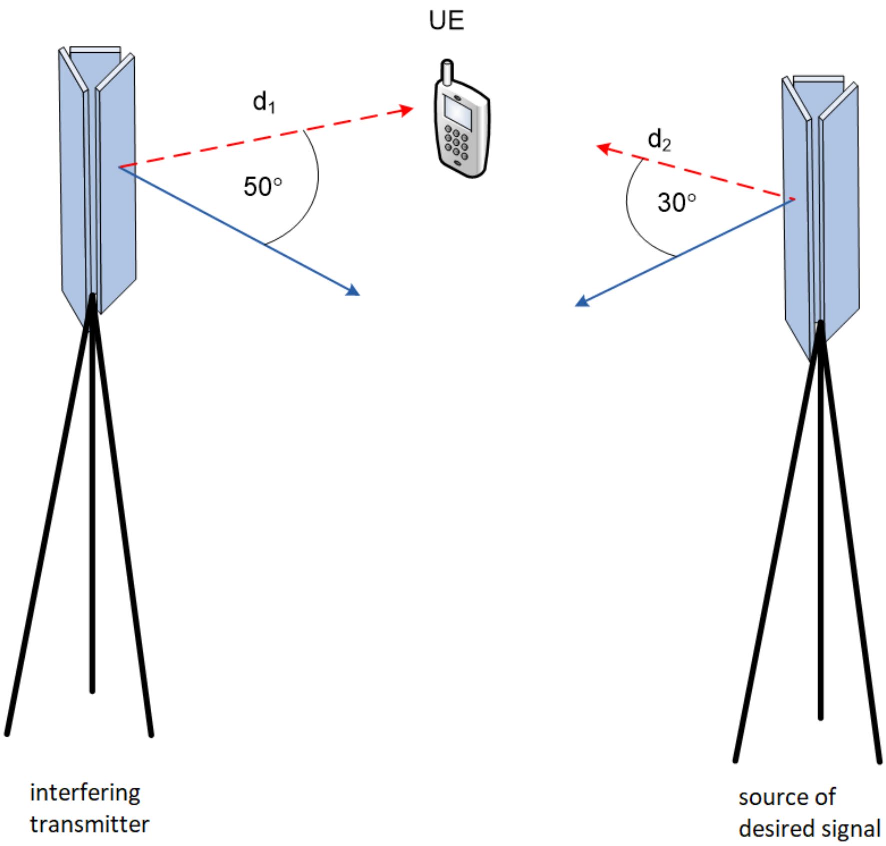
ABS seminar no.7

Interference in mobile communication systems

T.1

Channel interference

We consider the mobile communication system according to FIG.:



We assume that both BTSs use sector antennas with the same radiation pattern, and both transmit with the same power. The main direction of radiation of a given sector is indicated by a solid line. We know the distances: $d_1 = 300m$ and $d_1 = 200m$, and parameters:

$G_{\max} = 16\ dBi$, $\theta_0 = 0°$, $\theta_{3dB} = 60°$, $G_{fb} = 25\ dBi$.

Find the maximum SINR value that can be reached on the UE.

We assume average transmission losses:

$L(d) = 137{,}4 + 35{,}2\log(d)\ [dB]$, where d is distance in km

Analytical expression of directional gain of used antennas:

$$G(\theta) = G_{\max} + \max\left\{-12\left(\frac{\theta - \theta_0}{\theta_{3dB}}\right)^2, -G_{fb}\right\} \quad [dB]$$

, where:
θ [°] is the angle of incidence/reflection
$G_{\max}$ is the maximum gain of the antenna
θ_0 [°] is the angle in the direction of max. radiation
θ_{3dB} [°] is the width of the radiation beam for the drop in gain by 3dB
G_{fb} is the front-to-back radiation ratio

general relationship for SINR:

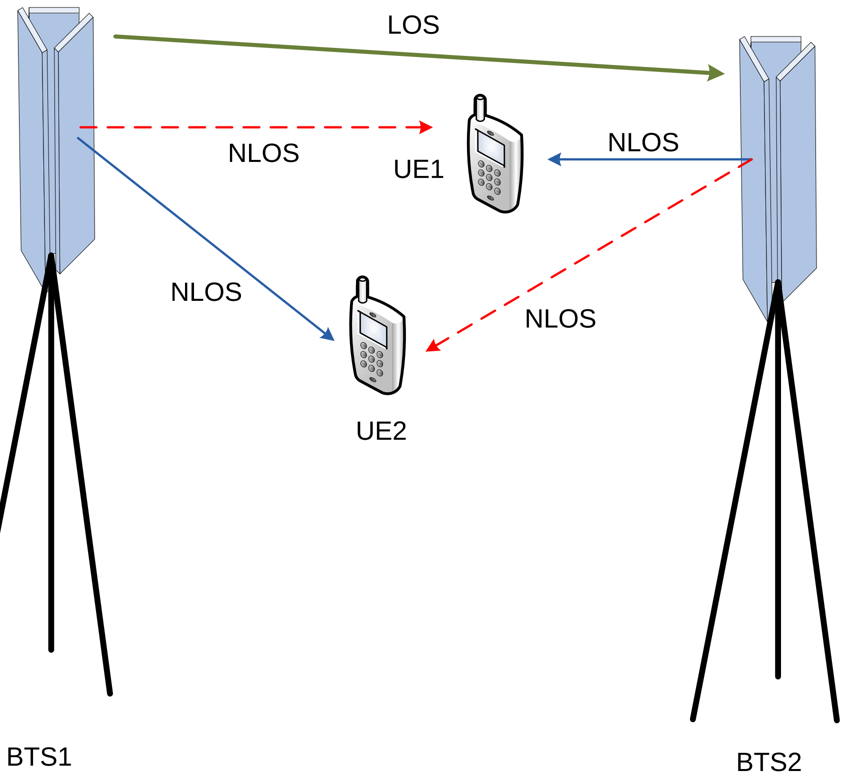
$$SINR = \frac{\frac{P_{2TX} G_2(\theta)}{L(d_2)}}{\frac{P_{1TX} G_1(\theta)}{L(d_1)} + P_N}$$

, where: $P_{1TX} = P_{2TX} = P_{TX}$ are BTS transmission powers

P_N is noise power

T.2

Cross-link interference in TDD systems
We consider the TDD mobile communication system according to FIG.:



System parameters:

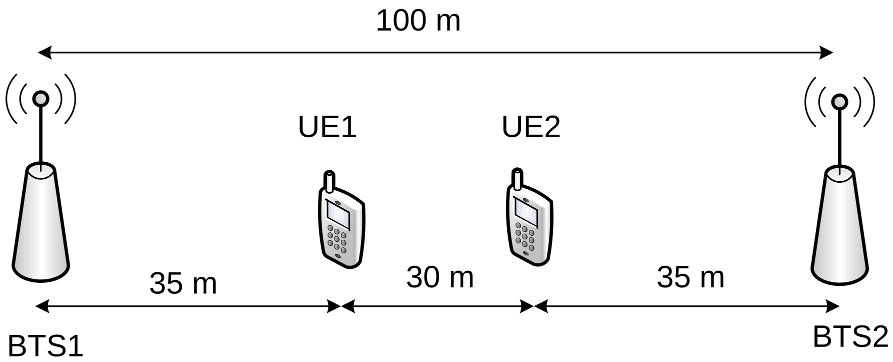
bandwidth: $W = 10\ MHz$
each UE is served by exactly one cell. UE1 is served by BTS1 and UE2 by BTS2.
the transmitted power of both UEs is the same: $P_{UE\,TX} = 23\ dBm$
the transmitted power of both BTSs is the same: $P_{BTS\,TX} = 30\ dBm$
power noise density in the channel: $N_0 = -174\ dBm / Hz$

the distance between the BTSs is: $d = 100\ m$
the distance between the BTS and each UE is: $d_1 = 35\ m$
UE1 transmits all the time in the UL direction
UE2 uses 3 different configurations:

1. 100% UL
2. 50% UL a 50%DL
3. 100% DL

a) What is the maximum transmission rate that UE1 can reach for each UE2 transmission mode configuration? (Use Shannon formula)
b) Estimate the upper limit of the bit rate for UE1 that it can reach in the UL direction?
c) What effect does the configuration in cell 2 have on the bit rate in cell 1?

Situational picture:

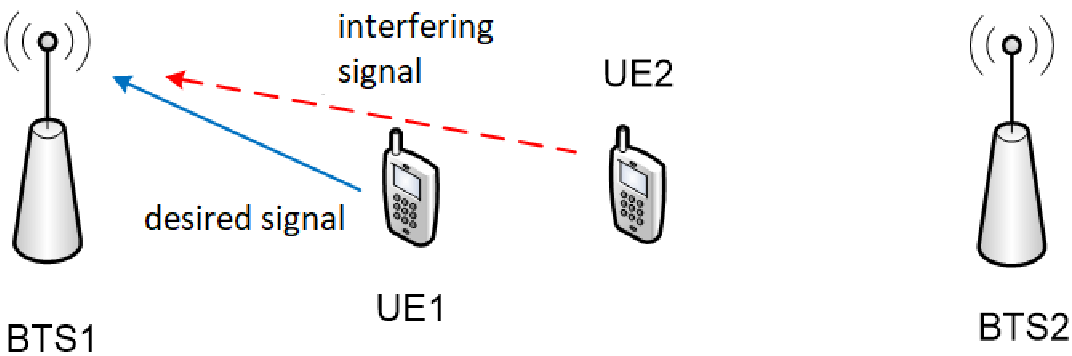


Average transmission losses for LOS and NLOS communication: → distance is in meters! (The previous formula was different because the distance was in km)

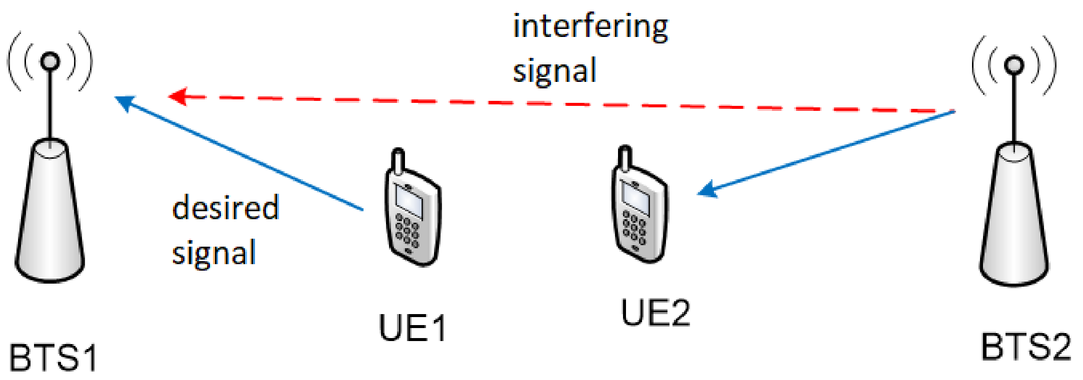
$L_{LOS}(d) = 16{,}9\log(d) + 38{,}8\ [dB]$

$L_{NLOS}(d) = 43{,}3\log(d) + 17{,}5\ [dB]$

Case 1.
UE1 still transmits UL direction
UE2 also still transmits UL direction



Case 2.
UE1 still transmits UL direction
UE2 still receives in the DL direction



Case 3.
UE1 still transmits UL direction
UE2 receives 50% in the DL direction and 50% transmits in the UL direction

capacity in this case will be the arithmetic mean of the capacities in the previous cases.

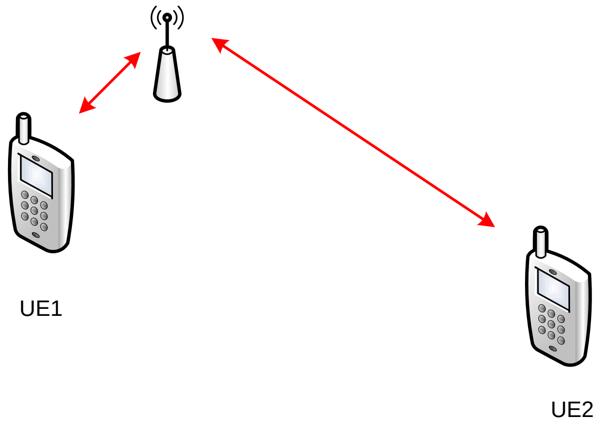
T.3

Timing Advance
We have a TDMA communication system. We assume two-way communication. The broadcast is divided into time slots, whereby: $T_b = 2\,\mu s$ and the transmission structure is as follows:

Number of bits	transmitted information
100	data and signaling
10	guard period

The guard period ensures the synchronization of the slots and compensates for the propagation delay caused by the unknown distance of the UE from the BTS. In order for the UE to remain synchronized with the BTS, it must receive a synchronization signal within the guard interval.

The farther the UE is from the BTS time slot, the more time it needs to come to the BTS. At some point, the time slot sent from the UE arrives at the BTS so late that it will be outside the defined interval and will interfere with an adjacent time slot intended for another user.



a)
Determine the maximum distance that the UE can be from the BTS so that the transmitted time slot arrives at the correct interval.

TA is a technique in which the BTS can notify the UE of the time interval by which they must advance their transmission to compensate for the propagation delay. The BTS analyzes the received special sequence from the UE and measures how much delayed it is compared to the expected time of arrival. At this time, it instructs the UE to advance its transmission.

b)
For a maximum cell radius of 15 km, specify the guard interval in bits.