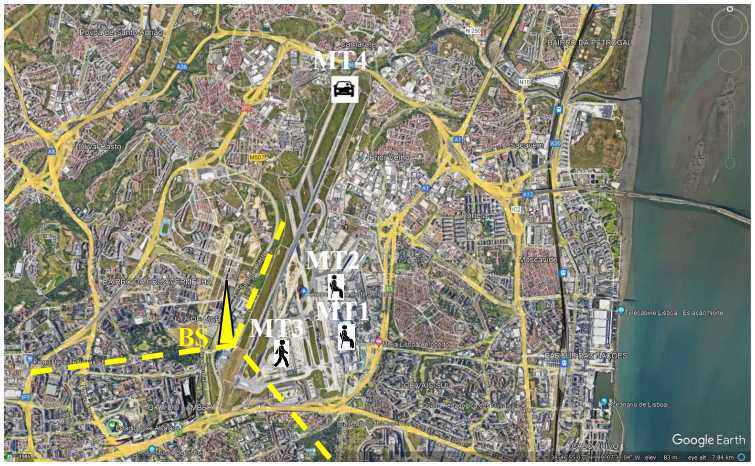
TÉCNICO LISBOA

Mobile Communications Systems
Master in Electrical and Computer Engineering
Prof. Luis M. Correia
27th Apr. 2023
Regular date Exam
2h00 duration

An operator has a Base Station (BS) on the rooftop of the logistics building at Lisbon Airport, with co-localised GSM/EDGE/900 (4 radio channels/sector), UMTS/HSPA+/900 (1 radio channel/sector), LTE/Class4/2600 (100 Resource Blocks) and NR/3600 (500 Resource Blocks μ=0) systems, sharing tri-sectorised dual-band dual-polarised diversity dipole antennas with 15 dBi gain (13º vertical half power beamwidth) down-tilted by 6º for the first three systems, and an active 8×8 antenna with 25 dBi for the last one, all fed by 47 dBm (the radio channels are always in the middle of each band, with GMS and UMTS adjacent to each other). Mobile Terminals (MTs) are considered to be multisystem smartphones, with a 0 dBi antenna, fed by 24 dBm, for any system. In all systems, the noise figure is considered to be 5 dB for the BS and 8 dB for the MT. The local cellular planning can be considered to be approximately uniform. This BS is intended to have a sector covering the non-built areas of the airport.



BS: antennas at a height of 8 m above ground level (80 m above sea level), the surroundings being considered flat.
MT1: person seating outdoors at the balcony of terminal building, 10 m above ground level, 1.2 km from the BS in LoS.
MT2: person seating indoors by the window at terminal building, 10 m above ground level, 1.2 km from the BS in LoS.
MT3: person walking (4 km/h), 0.5 km from the BS in LoS.
MT4: person driving (30 km/h), 3.3 km from the BS in LoS.

1. Take user MT3, connected to the GSM BS, performing a voice connection.

a) Calculate the average power received at the BS. Comment on the result. **[2.0]**

b) Would the value previously calculated be different if the connection would be done via UMTS or would be a data one? **[1.5]**

c) Estimate the horizontal half power beamwidth of the BS antenna and comment on the result. Do you expect the same value for the NR antenna? **[2.0]**

d) Would the coverage probability change depending on if the person walks towards or away from the BS? **[1.5]**

2. Take users MT1 and MT2, connected to the LTE BS, performing a data connection.

a) Do you expect the power delay profile to be the same for these two terminals? **[1.5]**

b) Should these terminals use the lowest modulation order in the connection? **[1.5]**

N.B.: All your answers must be justified.

c) Would the coherence time be the same for all terminals (MT1 to MT4)? **[2.0]**

d) Calculate the maximum diversity gain in SNR at the BS if MRC is used. **[1.5]**

3. Assume that the airport has 5 000 people (passengers and staff), a fifth of which can be considered to be communicating, with the following hourly averages: 2 voice calls with a 5 minutes duration each, 10 photo uploads of 200 kB each, and 20 accesses to news websites with a page size of 2 MB each.

a) Calculate the hourly traffic generated for voice and data. How many voice call users could be supported by a GSM sector, assuming a blocking probability of 1%? **[2.0]**

b) Would the carrier-to-interference ratio be the same for all terminals (MT1 to MT4)? **[1.5]**

c) Calculate the handover ratio for MT4, assuming that it is on the cell border. Comment on the result. **[1.5]**

d) Which systems would be adequate to carry the different types of generated traffic? **[1.5]**

Solutions

1.

a) -48.8 dBm (via the Flat Earth Model). The value is rather high, posing no coverage problems, but indicating that there can be interference ones, which should be dealt with by power control.

b) No. In this case UMTS is using the same 900 MHz band (with a minimum difference in the carriers), hence the received power is the same. In GMS, there's no difference between voice and data in the received power.

c) 100.3º. No, since the NR antenna has 25 dBi gain, so each lobe will have a much smaller beamwidth.

d) Yes. The probability will increase when the MT approaches the BS (the distance gets smaller, hence the attenuation also gets smaller, thus, the received power gets higher). The opposite happens when the MT goes away from the BS.

2.

a) No. In the indoor environment, one can expect more reflections to occur, hence, leading to a larger delay spread.

b) No. The highest data rate is achieved for the highest modulation order, so it should be used as much as possible.

c) No. Since the coherence time is inversely proportional to the speed of the MT, it will be different among MTs, with MT1 and MT2 having the highest (very large) value and MT4 the lowest.

d) 3 dB, for 2 antennas.

3.

a) 166.7 Erl and 42 GB. 117 users.

b) No. C/I depends on both the carrier and interference powers, which depend on the distances to the corresponding BSs, hence, there will be different values for the MTs.

c) 0.6. On average, there will be a handover every around two calls.

d) The adequate systems are: voice – GSM, UMTS (the others do not carry voice calls); photo – LTE, UMTS (it's a low data rate requirement, in a background service); web – LTE, NR (it's a medium data rate requirement, in an interactive service).