IT-Covilhã

Impact of propagation model on capacity in small-cell networks: comparison between the UHF/SHF and the millimetre wavebands

Radio Systems

Background and challenges

- This work aims at understanding and evaluating the impact of considering low (Ultra High Frequencies - UHF and Super High Frequency - SHF) and up (millimetre wavebands) frequency bands, using different path loss models in the optimization trade-off of small cell (SC) networks.

Description and main innovation

- Comparing the urban path loss models: the urban/vehicular and pedestrian test environment from the ITU-R M. 1255 Report, as well as the two slope urban micro Line-of-Sight (LoS) and Non-Line-of-Sight (NLoS), from the ITU-R 2135 Report for Ultra High Frequency (UHF). With upper bands (above 24 GHz) are assumed whilst considering the modified Friis propagation model

$$P_{LPed} = 40 \cdot log10(d_{[km]}) + 151.4492$$

$$P_{LUrb} = 38.40 \cdot log10(d_{[km]}) + 133.71$$

Outdoor-to-indoor / pedestrian (Ped) and urban (Urb) propagation models for UHF/SHF

$$d_{BP} = 4 \cdot h'_{BS} \cdot h'_{UT} \cdot f_c/c$$

f_c is the centre frequency, in Hertz, c=3.0 x 108 m/s is the propagation velocity in free space. The d_{BP} UMi LoS =156 m

$$P_{LUMiLoS}(d) = 22 \cdot log10(d_{[m]}) + 36.29947, d < 156 \text{ m}$$

$$P_{LUMiLoS}(d) = 40 \cdot log10(d_{[m]}) – 3.12788, d \geqslant 156 \text{ m}$$

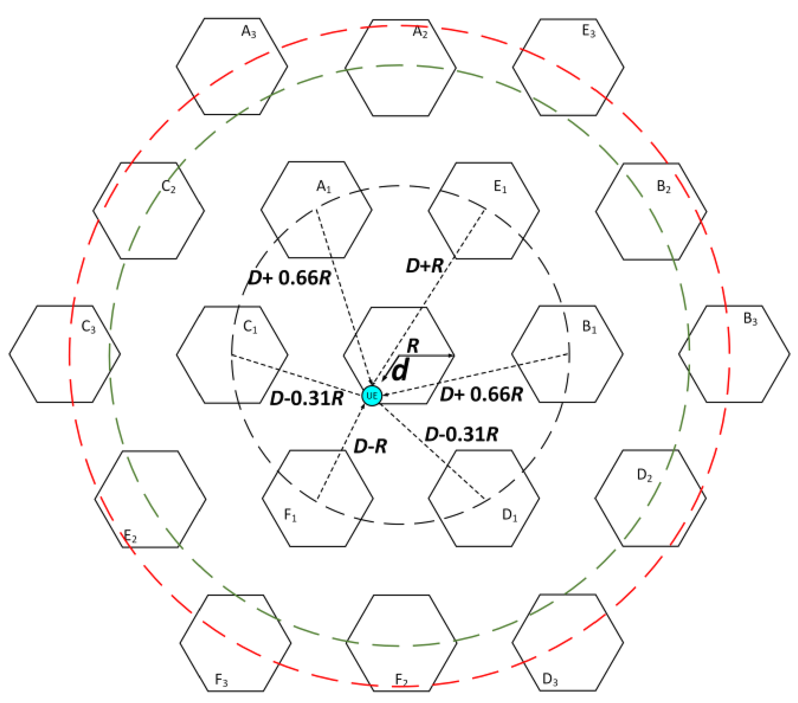
$$P_{LUMiNLoS}(d) = 36.7 log10(d_{[m]}) + 33.48$$

UMi LoS outdoor scenario with two-slope model, and UMi NLoS propagation models for UHF/SHF

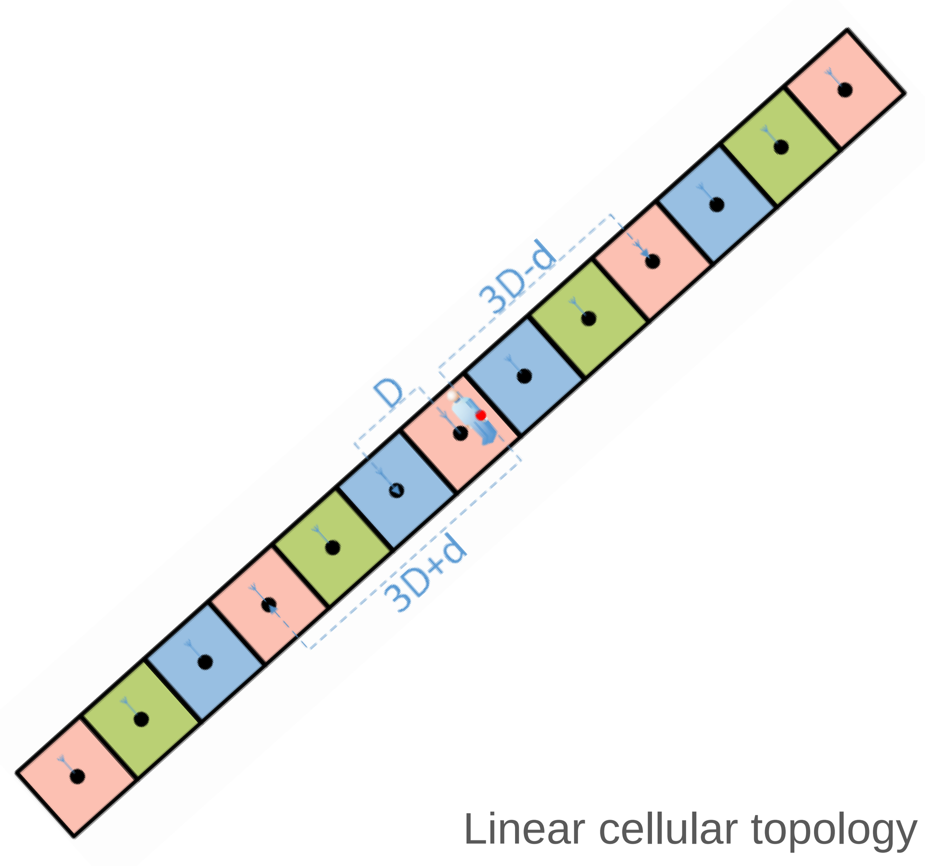
Parameter	UHF/SHF	mmWaves
Transmitter power [dBw]	-7	0
Transmitter gain [dBi]	17	3
Receiver gain [dBi]	0	0
Carrier [MHz]	20	20
Noise Figure [dB]	5	7
Height (Base Station) [m]	9	7
Height (User Equipment) [m]	0.5	1.5

$$PL_{LoS}\ [dB](d) = 20 log_{10}\left(\frac{4\pi}{\lambda}\right) + \bar{n} 10 log_{10}\ (d) + X_\sigma, d \geqslant 1m$$

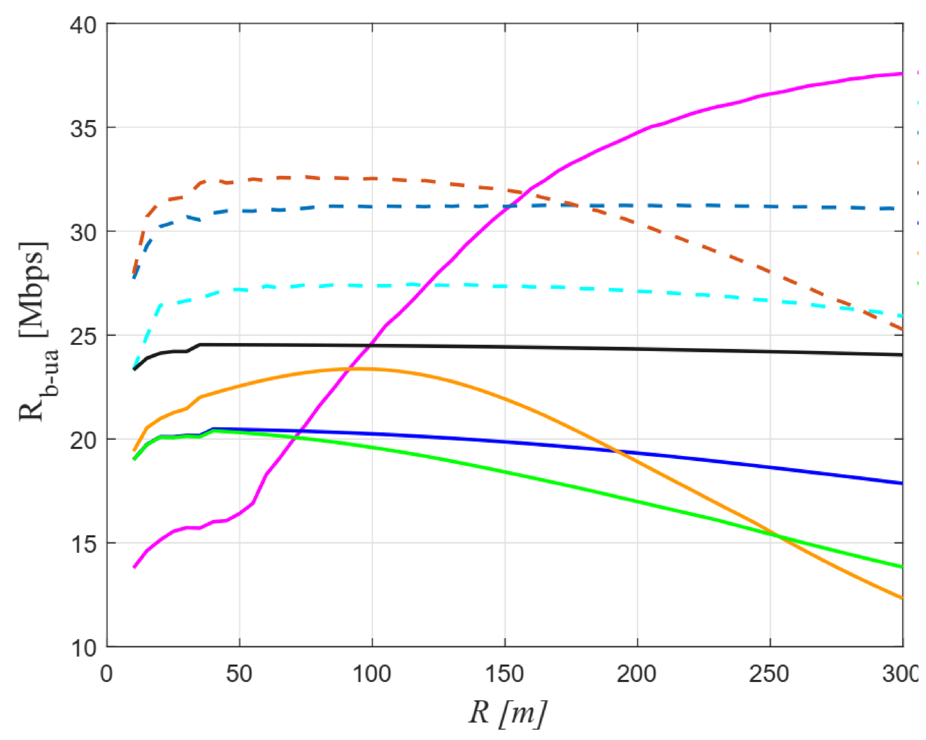
Friis propagation models for Millimetre Wavebands, where Xσ is the typical log-normal random variable with 0 dB mean and standard deviation σ, in decibels, and models shadow fading.



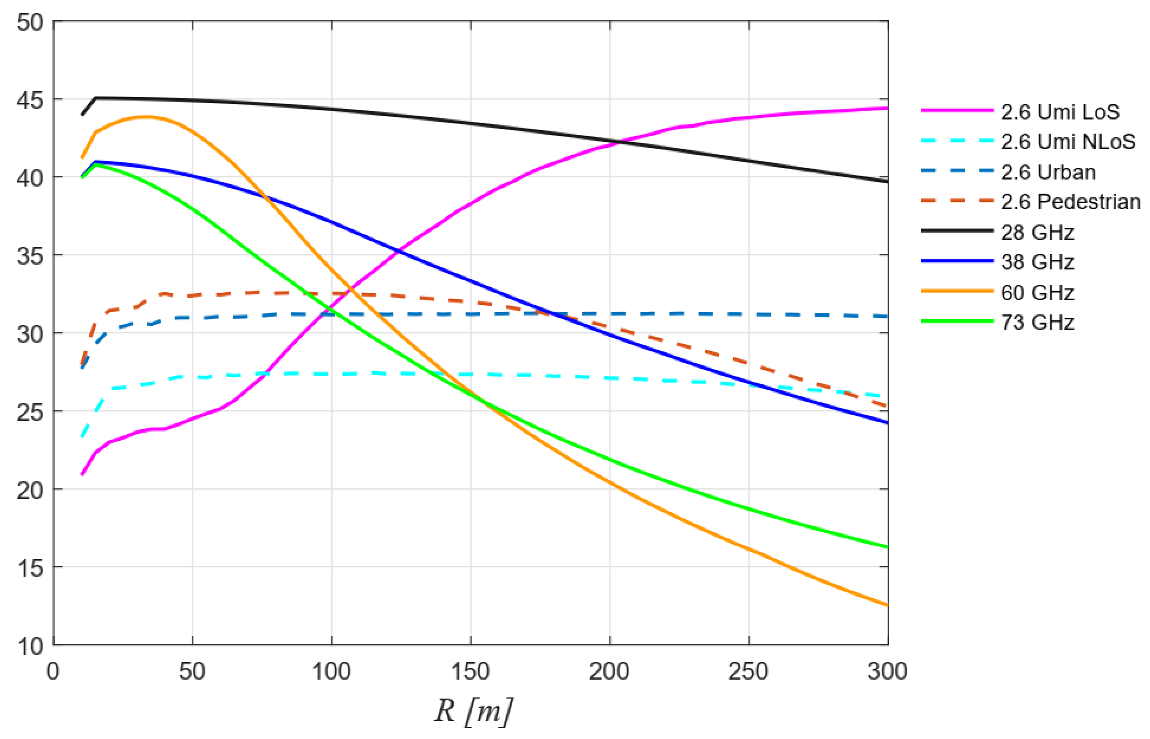
Hexagonal cellular topology



Linear cellular topology



Equivalent supported throughput for Hexagonal topology



Equivalent supported throughput for Linear topology

Comparison of equivalent supported throughput between UHF/SHF and mmWaves for BW = 20 MHz.

- Overall, the supported throughput is higher for the 28 GHz frequency band compared to 38 GHz but the 60 GHz frequency band only performs better than the 73 GHz band for Rs up to approximately 150 m. Therefore, the throughput for the 73 GHz frequency band is higher. This is due to the O2 attenuation excess which causes a reduction in the coverage at 60 GHz [1].
- For longer Rs, the supported throughput is clearly higher for UHF and SHF frequency bands

Achievements

- The comparison between Super High Frequency and millimetre wavebands in outdoor environments, the evaluation comprises the study of the performance the supported throughput for 2.6, 3.5, 28, 38, 60 and 73 GHz.
- For short coverage distances the supported throughput at 28, 38, 60 and 73 GHz is higher than the supported throughput at 2.6/3.5 GHz, mainly due to the reduction that characterizes the application of the two-slope propagation model at the UHF/SHF bands. Then, for short distances, the supported throughput is clearly higher for millimetre wavebands.
- We assume in this preliminary phase that LTE is considered for the millimetre wavebands (but other air interfaces will also be assumed).

[1] E. Teixeira and F. J. Velez, "Cost/Revenue Trade-Off of Small Cell Networks in the Millimetre Wavebands," 2018 IEEE 87th Vehicular Technology Conference (VTC Spring), Porto, 2018, pp. 1-6. doi: 10.1109/VTCSpring.2018.8417623

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