Simulation Configuration

The setup of a specific simulation is based on configuring the variables of five main data frames located in the main.py file. Such data frames are listed below, describing their variables, possible values, and functional descriptions. The data frame configuration (through the main.py file) can be saved as independent Excel files, one for each data frame, by setting *save_simulation_settings = True.* Then, the simulation configuration can be set directly from the previously created Excel files by setting *simulation_settings = "from_excel"*.

1. **general_simulation_parameters** (pd.DataFrame)

Variable Name	Value (e.g.,)	Description
grid_xy	"[100, 100]"	Definition of the simulation grid's x and y in meters (m). It must be defined as a string to ensure saving and uploading in and from the configuration Excel.
grid_center_latitude	39.2137738	Latitude in degrees of the grid center, default value: grid_center_lat = 39.2137738 degrees, used for non-terrestrial network (NTN) simulations.
grid_center_longitude	9.1153844	Longitude in degrees of the grid center in degrees, default value: grid_center_lat = 9.1153844 degrees, used for NTN simulations.
simulation_time	10	Simulation time in seconds (s).
simulation_resolution	0.1	Simulation resolution, e.g., 1 means a one-second resolution (one sample per second), 0.1 means a 0.1-second resolution (100 ms), or ten samples for every second.
downlink	True	To enable the downlink computation from the base stations (BSs) to the end-devices (EDs).
uplink	False	To enable the uplink computation from the EDs to the BSs. **TODO** is not enabled between the EDs and the NTNs.
d2d_link	False	To enable the device-to-device (D2D) link computation among EDs.
ntn_link	True	To enable the link computation between the available NTNs (e.g., LEO, MEO, HAPS) and the EDs.
save_scenario_xlsx	False	To save (./output/scenario/) as .xlsx the simulated scenario. It means the coordinate x, y, and z of each EDs or BSs or the latitude, longitude, and altitude (LLA) of the NTNs.
save_metrics_xlsx	False	To save (./output/metrics/) the resulting LLS outputs: SINR, CQI, BLER, among each ED and each BS (TN/NTN) or EDs for D2D communications, as .xlsx.
show_video	True	Boolean to enable or disable the simulation video display regarding the grid and the configured BSs and EDs with their mobility behavior. (The link computation is executed after we close the video).
video_format	"gif"	("mp4", "gif", "Both"). For now, the video format (in the general_simulation_parameters input data frame) can be saved as a .gif file.
video_velocity	0.1	Float variable for modifying the video velocity. Default value: 0.1.
print_scenario_outputs	True	A Boolean to enable printing the scenario output. It means the coordinates x, y, and z of each EDs or BSs or the LLA of the NTNs.
print_metrics_outputs	True	Boolean to enable printing the resulting simulation metrics: SINR, CQI, BLER, among each ED and each BS (TN/NTN) or EDs for D2D communications.

2. **general_channel_modeling** (pd.DataFrame)

Variable Name	Value (e.g.,)	Description
dynamic_los	False	Boolean, where True means a dynamic Line of Sight (LOS). Regarding each BS, a user could be in LOS or non-LOS (NLOS). False means only LOS.
dynamic_hb	False	Boolean, where True means a dynamic human blockage (HB) in the link between the BS and the ED (mainly used for mmWave simulations). False means no HB considerations.
o2i	False	Boolean where True means a dynamic outdoor-to-indoor (o2i), a user could be simulated in o2i or not conditions regarding the BS (It means NLOS). False means only LOS.
inside_what_o2i	"dynamic"	("dynamic", "building", "car"). "dynamic" means that it will be chosen randomly if the user is inside a building or a car; it will modify the penetration losses considered. The other options are to fix or inside a building or a car.
penetration_loss_model	"low-loss"	("low-loss", "high-loss"). According to 3GPP TR 38.811: 6.6.3 O2I penetration loss for NTN simulations only. Low-loss means a traditional building type, while high-loss means a thermally efficient one.
shadowing	True	Boolean for enabling the shadowing fading (slow-fading) attenuation in the link.
fast_fading	True	Boolean for enabling the fast-fading attenuation in the link according to jakes, tdl or cdl (**TODO** CDL is not enabled for NTN links).
fast_fading_model	"jakes"	("jakes", "tdl", "cdl") TDL and CDL are implemented according 3GPP TR 38.901 (**TODO** CDL is not enabled for NTN links).
atmospheric_absorption	False	Boolean for enabling the atmospheric absorption attenuation in the link.
desired_delay_spread	"Very short"	("Nominal", "Very long", "Long delay", "Short", "Very short", None). 3GPP TR 38.901, Table 7.7.3-1. Example scaling parameters for CDL and TDL models.

3. general_parameters (pd.DataFrame)

Variable Name	Value (e.g.,)	Description
thermal_noise	-174	The value -174 dBm/Hz is commonly used to represent the thermal noise power spectral density at room temperature (approximately 290K).
h_ceiling	10	Considered height of the buildings (in m). This is only used for InF link modes and must be equal to or lower than 10 meters.
block_density	0.2	Human block density, valid when "dynamic_hb" is True. block_density = 1, which means that if "dynamic_hb" is True, it will always be considered HB penetration attenuation. block_density = 0, means zero probability of HB.
channel_type	"real"	("real", "awgn"). Used for the link to system adaptation process and computing the users CQI feedback or using the real BLER (Block Error Rate) or AWGN curves. When FF and Shadowing are considered, the channel type must always be real.
target_bler	0.1	typical values (0.1, 0.01). It is the target BLER for selecting the user's CQI.

4. bs_parameters (pd.DataFrame)

Variable Name	Value (e.g.,)	Description
x	50	For "tbs"/"abs": Int value. x coordinate (in m) of the BS. For "sat": latitude of the satellite. It defines the satellite's elevation angle regarding the grid's center (in degrees).
y	50	For "tbs"/"abs": Int value. y coordinate (in m) of the BS. For "sat": the satellite's longitude. It defines the satellite's elevation angle regarding the grid's center (in degrees).
z	25	For "tbs"/"abs"/"sat": Int value. z coordinate (in m) of the BS (height of BS). It defines the satellite's elevation angle regarding the grid's center (in degrees).
type	"tbs"	("tbs", "abs", "sat"). For defining if the BS is a terrestrial (TN) BS, or an Aerial BS (a BS on top of a UAV), or a satellite NTN.
scenario	"UMa"	for tbs:("UMi", "UMa", "RMa", "InH-Mixed", "InH-Open", "InF-HH", "InF-SL", "InF-DL", "InF-SH", "InF-DH", "D2D"), for abs ("A2G"), for sat ("HAPS", "LEO", "MEO"). **TODO** for the NTN (type = sat) this is not considered.
antenna_mode	"three_sectors"	for tbs and abs: ("omni", "three_sectors", "four_sectors", "one_sectors_90_degrees"), for sat: ("omni", "Sat_ax").
ax_panel_polarization	"dual"	("single", "dual"). For considering an antenna with single or dual polarization elements.
fast_fading_los_type	"E"	("D", "E"; NTN: "C_ntn", "D_ntn"), according to 3GPP TR 38.901/38.811.
fast_fading_nlos_type	"B"	("A", "B", "C"; NTN: "A_ntn", "B_ntn"), according to 3GPP TR 38.901/38.81.
fc	28	float from 0.5 to 100 Gigahertz (frequency of the BS).
numerology	2	(0, 1, 2, 3, 4) numerology of the BS according to 5G NR, 3GPP TS 38.214.
n_rb	1	Int with the number of physical resource blocks (RBs).
p_tx	20	Transmission (tx) power of the BS in dBm.
ax_gain	20	Antenna (ax) gain of the BS in dBi.
cable_loss	2	Cable loss, default value 2 dB.
noise_figure	7	Noise Figure, default value 7 dB.
v_tilt	15	Vertical tilt of the BS antenna, default value 15 degrees.
desired_elevation_angle	None	The desired elevation angle (in degrees, from 1 to 90) of the satellite regarding the center of the grid (in degrees) is just used for comparison with the real elevation angle configured to the Sat from their LLA coordinates and the grid coordinates. In the case of type ="tbs" or "abs" it must be set as None.

Examples of configurations.

- [50, 50, 25, "tbs", "UMa", "three_sectors", "dual", "E", "B", 2.4, 2, 1, 20, 20, 2, 7, 15, None],
- [75, 75, 10, "tbs", "UMi", "three_sectors", "dual", "D", "A", 28, 2, 1, 10, 10, 2, 7, 15, None],
- [25, 25, 10, "abs", "UMi", "three_sectors", "dual", "D", "A", 28, 2, 1, 10, 10, 2, 7, 15, None],
- [39.2337738, 9.12153844, 50000, "sat", "HAPS", "Sat_ax", "dual", "C_ntn", "A_ntn", 2, 2, 50, 36, 30, 2, 7, None, 85],
- [39.2137738, 9.1153844, 50000, "sat", "HAPS", "Sat_ax", "dual", "C_ntn", "A_ntn", 2, 2, 50, 36, 30, 2, 7, None, 90],

5. sub_groups_parameters (pd.DataFrame)

Variable Name	Value (e.g.,)	Description
type	"pedestrian"	("pedestrian", "car_mounted", "iot"). These classifications are only used to identify among three possible kinds of simulated EDs.
k_sub	10	Int, the number of EDs to simulate.
antenna_mode	"omni"	("omni", "three_sectors")
p_tx	0	Transmission (tx) power of the ED in dB.

ax_gain	0	Antenna (ax) gain of the BS in dBi. The ax_gain is considered a 0 if the antenna_mode = "omni".
cable_loss	0	Cable loss, default value 2 dB.
noise_figure	7	Noise Figure, default value 7 dB.
d2d	True	Boolean for enabling the D2D capability of this EDs
fixed_height	True	Boolean for enabling an scenario definition where all the ED have the same and fixed height. fixed_height = true min_max_height[mg][0] = min_max_height[mg][1].
grid_size_ratio	"[1, 1]"	Array of two Double parameters (between 0 and 1) (grid_size_ratio[0], grid_size_ratio[1]). grid_size_ratio[0], grid_size_ratio[0] = 1 means that the users will be randomly distributed in 100% of the grid regarding the x and y coordinates. grid_size_ratio[0], grid_size_ratio[0] = 0.1 means that the users will be randomly distributed in 10% of the grid regarding the x and y coordinates. The x grid_size_ratio[0] and y grid_size_ratio[1] percents that can be configured independently. It must be defined as a string to ensure saving and uploading in and from the configuration Excel.
reference_location	"[50, 50]"	Array of two int values (reference_location[0], reference_location[1]), for defining the center reference location where the users will be simulated. x = reference_location[0], y = reference_location[1]. It must be defined as a string to ensure saving and uploading in and from the configuration Excel.
min_max_velocity	"[0.4, 1.2]"	Array of two float values (min_max_velocity[0], min_max_velocity[1]), for defining the minimun and maximun velocity (m/s) that the users could experience. It must be defined as a string to ensure saving and uploading in and from the configuration Excel.
wait_time	1	Float value for defining the wait time (s) that the users with a certain mobility could experience. It means that the users in their trajectory could be static for the defined "wait_time".
mobility_model	"Random Waypoint"	("Random Static", "Random Walk", "Random Waypoint", "Truncated Levy Walk model", "Random Direction model", "Gauss-Markov model", "Reference Point Group model"), s.t., https://github.com/panisson/pymobility.
aggregation	None	Double, parameter (between 0 and 1). The parameter 'aggregation' controls how close the nodes are to the group center. It is only valid for the "Reference Point Group model"; otherwise, it is None.
number_mg_rpg_model	None	The parameter 'number_mg_rpg_model' is an Int value that defines the number of sub-groups; k_sub/number_mg_rpg_model must be an integer. It is only valid for the "Reference Point Group model"; otherwise, it is None.
min_max_height	"[1.5, 1.5]"	Array of two float values (min_max_height[0], min_max_height[1]), for defining the min and max height of the EDs. When fixed_height is equal true min_max_height[0] = min_max_height[1]. It must be defined as a string to ensure saving and uploading in and from the configuration Excel.
rx_scenario	"urban"	("dense urban", "urban", "suburban", "rural"). This is only used for type = "sat".

Examples of configurations.

- ["pedestrian", 10, "omni", 0, 0, 0, 7, True, True, "[1, 1]", "[50, 50]", "[0.4, 1.2]", 1, "Random Waypoint", None, None, "[1.5, 1.5]", "urban"],
- ["pedestrian", 10, "three_sectors", 0, 0, 0, 7, True, False, "[0.5, 0.5]", "[150, 150]", "[1, 5]", 1, "Random Direction model", None, None, "[1.5, 1.5]", "urban"],
- ["car_mounted", 1, "three_sectors", 10, 10, 0, 7, True, False, "[1, 0.2]", "[50, 75]", "[10, 15]", 1, "Random Waypoint", None, None, "[1.5, 1.5]", "urban"],
- ["iot", 1, "three_sectors", 10, 10, 0, 7, True, False, "[0.25, 0.25]", "[75, 75]", "[0.0001, 0.0002]", 1, "Random Waypoint", None, None, "[1.5, 1.5]", "urban"]