Modelling of Building Height Interference Dependence in UMTS

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Abstract—The main purpose of this paper is to study the interference dependence in UMTS-FDD with the buildings height. For this, an interference model was developed, and implemented in a simulator. This model calculates intra- and inter-cell interference independently in DL and UL. Some simulations results were compared with measurements performed in a live network in order to assess the simulator. With the purpose of knowing how interference behaves, several simulations were performed, changing some parameters, such as the distance between MT and BS, centre building height, street widths, antennas tilts and number of BSs. The simulations results show that the interference has its higher value in the case of rooms directly facing the outside, and it also shows an increase trend of 2.5dB per floor, and a difference of 2.8dB between each penetrated wall situation. This result is different when the analysis is performed in terms of NLoS and LoS. In the case of NLoS, the interference has a rise of 1.3dB per floor, and 3.3dB in the case of LoS, i.e., when the MT is in LoS the slope increases almost two times faster than when it is in NLoS. The principal conclusion was: the higher the MT is in the building, and the less penetrated wall it has, the higher the interference will be.

Keywords—UMTS; WCDMA; FDD; Interference; Modelling.

I. INTRODUCTION

Nowadays, mobile communications systems have become an important infrastructure in our society. When working in the world of radio waves, which see no arbitrary boundaries, and geographic licensing, interference issues always will crop up. Interference is a physical phenomenon which exists and will always exist in different ways on mobile communications. Since the last decade, studies on the interference field have been growing because the capacity in WCDMA network is limited by interference. Thus its evaluation is one of the fundamental procedures for WCDMA systems planning.

In the network planning, an important point that cannot be neglected is the environment. Planning tools, key elements for efficient dimensioning of a network, usually provide only outdoor coverage predictions. However, mobile phones are used everywhere, not only outdoor, but more and more indoor. In all these environments, customers demand a good coverage and quality of service. So, it is normally estimated the path loss from the BS to the centre of the street where MTs are assumed to be plus an extra signal attenuation associated to building penetration. Building construction characteristics and city morphology have a strong impact on propagation characteristics, which makes the correct adaptation of extra signal attenuation estimation associated to building penetration through propagation models, or to predictions extracted from measurement campaigns a difficult task. In [1] and [2] this subject is deeply approached. All these aspect have a relevant effect in interference.

In UMTS operating in FDD, interference happens mainly between Mobile Terminal (MT) and Base Station (BS) and between BS and MT, due to its nature. The total interference experienced by a mobile is composed of two parts: intra-cell interference and inter-cell interference. The intra-cell is the interference created within one cell, it caused or effected by MTs or by BS of that cell. The inter-cell is the interference caused by MTs or BSs out of the range cell on study.

In [3], [4], [5] and [6], models for intra-cell interference in UL way calculation are presented. These models take the perfect power control into account, i.e. the signals arrived at BS have same power. In [3], the interference calculation is performed taking into account the service and the number of users using that service. This model obtains the maximum number of users in each service within the system and it does not take the slow fading effects into account. In [4], the model depends on the inter-cell one, the number of users, the service used, and the target equivalent Signal-to-Noise Ratio (SNR), Eb/N0 relation. So, the inter-cell interference is taken as known a priori in the interference calculation. As [4], in [5] the intra-cell depends on inter-cell interference, however this model calculate the mutual generated load between all cells in the network in order to obtain the inter-cell interference, and then the intra-cell. In [6], power received by BS, activity factor of the service and number of users using that service are the parameters used in the interference calculation, and uniform distribution by users is assumed.

In the case of intra-cell interference in DL, in [7] the model uses the following parameters: total average received power of MT, path loss, orthogonality loss between codes. This model does not take slow fading into account. In [8], the model present two ways for interference calculation, when hard handover and other while soft handover is considered. For hard handover this model takes into account: orthogonality factor, path loss, total power transmitted of BS to MTs within the cell and log-normal distribution for the slow fading. For soft handover the model is the same, but with one additional parameter: number of users of adjacent cells in handover situation.
In [6], it is also suggested a model for inter-cell interference calculation in UL. It takes received power by BS, service, number of users using that service, activity factor and the distribution of users into account. Perfect power control is assumed and multi-services are supported. However, this model gives the inter-cell interference average per cell in all its area. In [9], the previously described model is the same with a difference, they do not consider a non-uniform user distribution statistical function in the cell area, i.e., instead of integrating the user distribution function in the cell area, a sum of all users’ distance to their serving BSs is taken into account. A model based in the MTs transmitted power, the MTs to BSs distances, and slow fading with log-normal distribution, it is presented in [10]. It is also consider in this model: the signals are mutually independent among each others and users are uniformly distributed in the cell.

So for the last interference calculation, in [11] inter-cell interference in DL is explored. For its calculation it is taken into account the total transmitted power of BS, the path loss, slow fading with a uniform distribution, distance from the mobile to BS and the angle that MT does with BS. However, this model does not allow multi-service. So, in [9] as a way to allow the multi-service the orthogonality factor parameter is added.

In Section II the models used for interference calculation are presented, as well as the propagations models out- and indoor. Section III contains a brief description of the simulator. The default scenarios, the results for some parameters variation as well as the results obtained in the measurements are presented and analysis in Section IV. Finally, conclusions are in Section IV.

II. THEORETICAL MODELS

A. Interference Model

1) Intra-Cell in UL

The model used for the calculation of this kind of interference is given by [6]:

$$I_{intra,[W]}^{UL} = \sum_{g=1}^{Ngs} P_{MT \rightarrow BS} \times \eta_g \times N_{j,g} \times A \times L_p,$$

where $P_{MT \rightarrow BS}$ is the power received in the BS $j$ from an MT, $\eta_g$ is the activity factor of service $g$, $N_{j,g}$ is the number of MTs using service $g$ on the cell of BS $j$ and $N_{gs}$ is the total number of services used. Despite, this model takes the interference from all services into account, it is only calculated the interference for the service one service.

2) Intra-Cell in DL

The interference model for intra-cell interference in DL, on MT $i$, is calculated by [8]:

$$I_{intra,[W]}^{DL} = \left( P_{Total,BS} - P_{BS \rightarrow MT} \right) \times \alpha \times L_p,$$

where $P_{Total,BS}$ is the total transmitted power from BS, $P_{BS \rightarrow MT}$ is the power transmitted by the BS to the MT in which interference is being calculated, $\alpha$ is the orthogonality factor and $L_p$ is the path loss between the BS and the MT in which interference is being calculated.

3) Inter-Cell in UL

In case of inter-cell interference calculation in UL, on BS $j$ is given by [9]:

$$I_{inter,[W]}^{UL} = \sum_{k=1, k \neq j}^{Nbs} \sum_{g=1}^{Ngs} P_{MT_k \rightarrow BS_j} \times L_p \times \eta_g \times A,$$

with

$$A = \sum_{n=1}^{N_{k,n}} r_{k,n} \times a,$$

where $P_{MT_k \rightarrow BS}$ is the MT $k$ power transmitted to BS $j$ in an adjacent cell, $N_{k,g}$ the number of users using service $g$ in interfering cell $k$, $r_{k,n}$ the distance from MT $n$ using service $g$ to BSs $k$, $r_{k,n}$, the distance from MT $n$ using service $g$ to BSs $j$ and $a$ the average power decay.

4) Inter-Cell in DL

For inter-cell interference in DL, the interference in one MT $i$ using the service $g$ is calculated according to [9]:

$$I_{inter,[W]}^{DL} = \sum_{j=2}^{N_{bs}} P_{Total,BS} \times \alpha \times L_p,$$

where $P_{Total,BS}$ is the BS $j$ total transmitted power, including antenna gain and $N_{bs}$ is the number of interfering BSs.

B. Path loss Model

The path loss has an important role in the interference prediction. So, for its calculation different models are used concerning the situation, and it is also combine the outdoor models with the indoor. The algorithm behind its combination is shown in [12].

1) Outdoor Models

One of the four models used in [12], it is the free space, which is given by:

$$L_{0[db]} = 20 \log(d_{km}) + 20 \log(f_{MHz}),$$

where $d$ is the distance between BS and MT and $f$ is the frequency. Other one is the COST 231 – Walfish-Ikegami [13]. In case of LoS the model is given by:

$$L_{rs}[db] = 42.6 + 20 \log(d_{km}) + 20 \log(f_{MHz}),$$

and in case of NLoS the path loss is given by:

$$L_{rs}[db] = \begin{cases} L_{0}[db] + L_{rs}[db] + L_{soft}[db] & \text{for } L_{rs} + L_{soft} > 0, \\ L_{0}[db] & \text{for } L_{rs} + L_{soft} \leq 0, \end{cases}$$

where $L_{soft}$ is the multiple screen diffraction loss, and $L_{rs}$ the roof-top-to-street diffraction and scatter loss. The last one is the free space plus an extra attenuation due to diffraction from the roof to the MT and it is given by [14]:

$$L_{rs}[db] = L_{0}[db] + L_{soft}[db],$$

where $L_{F}$ is the extra attenuation that is given by:
\[ L_{\text{p,ind}} = -20 \log \left( \frac{1}{\pi k_f} \left( \frac{1}{\theta_{\text{ind}}} - \frac{1}{2\pi - \theta_{\text{ind}}} \right) \right) \], (11)

and \( \theta \) is the angle between MT and Roof-Top defined by (12), \( k \) the propagation constant that is given by (13), \( r \) the distance between roof-top and the MT given by (14).

\[ \theta_{\text{ind}} = \tan^{-1}\left( \frac{\Delta h_{\text{Mobile}}}{x} \right), \] (12)

\[ k = \frac{2\pi f_{\text{MHz}}}{300}, \] (13)

\[ r_{\text{f}} = \sqrt{(\Delta h_{\text{Mobile}}^2 + x^2)}, \] (14)

where \( \Delta h_{\text{Mobile}} \) is the difference between the roof height and the mobile height and \( x \) the horizontal distance between the MT and diffracting edges.

These models are used according some condition, in Table I is summarised each situation.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Propagation Models</th>
</tr>
</thead>
<tbody>
<tr>
<td>LoS</td>
<td>Description</td>
</tr>
<tr>
<td>Yes</td>
<td>Distance between BS and MT is less than 20m</td>
</tr>
<tr>
<td>Yes</td>
<td>BS on adjacent building facade, distance between BS and MT is less than 20m</td>
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<tr>
<td>Yes</td>
<td>BS on adjacent building facade, distance between BS and MT is more than 20m</td>
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<td>Yes</td>
<td>Distance between BS and MT is more than 20m</td>
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<tr>
<td>No</td>
<td>Distance between BS and MT is more than 20m</td>
</tr>
<tr>
<td>No</td>
<td>BS on adjacent building top, distance between BS and MT is less than 20m</td>
</tr>
</tbody>
</table>

2) Indoor Model

The indoor model is based on [13], the Multi-Wall model (MWM), which is given by:

\[ L_{\text{p,ind}} = L_{Q,\text{ind}} + L_{\text{glass}} + k_i L_{\text{f}} + k_f L_{\text{f}}, \] (15)

where \( k_i \) is the number of penetrated walls of type \( i \), \( k_f \) the number of penetrated floors, \( L_{\text{f}} \) the loss attenuation of wall type \( i \), \( L_f \) the floor loss attenuation and \( L_{\text{glass}} \) the glass loss attenuation. However, The MWM model given by (15) is the general case, two variations of this model were used. The first is when the MT is served by one BS in the building top, the calculation is done according to (16). In this particular case, the attenuation does not depend on MT position on the floor, i.e. the loss only depends on the floor numbers between MT and BS plus the free space. The other one is the most common case, when the BS is not in the same building as MT, the calculation is done according to (17). Notice \( k_i \) is equal to 0 when BS is in LoS with the MT.

\[ L_{\text{p,ind}} = L_{Q,\text{ind}} + k_f L_{\text{f}} \] (16)

\[ L_{\text{p,ind}} = k_i L_{\text{f}} + L_{\text{f}} + L_{\text{glass}} \] (17)

III. SIMULATOR

The simulator used in this work, UMIINS, is a spatial one, being composed by three main blocks [12]: configuration, simulation and results.

In the configuration block, all the initial system planning and parameterisation is done. It is in this point that the user chooses what kind of scenario he wants: dense urban, urban, suburban or a different scenario created by him. It is also chosen the characteristics of the centre building (height and number of floors), the users (number of users, percentage of voice and data service, percentage of mobility), the BSs (number of BSs, position and radiation pattern) and the overall parameters, like frequency and standard deviation for fading distributions and BSs antennas tilt.

In the simulation block, BSs are distributed according to its coordinates. The users are distributed uniformly around the scenario. After placing the users, the network is deployed. Then a first network analysis is performed, the cell radius for a single user is calculated for each service, according to the model COST231 – WINLoS. All the users within the coverage area are candidates to be served. After knowing the users in the coverage area, they need to pass through three phases, in which priority is given to the users nearer to the BS. The first test is the load factor that can not be more than 75% in DL and 50% in UL. The second test is the transmitter power sum, which can not be more than BS maximum transmitter power. For the last test, the codes for each service can not be more than its limits. After all the configurations and parameters filled in, the interference is calculated.

In the last block, results, as the name suggests, the results of the simulation, interference values of inter-cell and intra-cell in DL/UL are saved in files.

IV. RESULTS ANALYSIS

A. Reference Scenario

It is important to have a reference scenario, to which comparisons are performed when some parameters are modified. This reference scenario should be chosen in such a way that it represents a possible real network.

The user in analysis is in the central building, using the reference service that is based on 12.2kbps Voice, and its location is random on each floor. For the scenario, the values that fit better the city of Lisbon were taken into account. Therefore, the scenario type is a dense urban with 21 m of buildings height, 40 m of buildings separation and 12 m of streets width. The centre building has 11 floors with 3 m
height per floor and 33 m of building height. The environment has 100 users, being 50, 25 and 25 for indoor, pedestrian and vehicular mobility, respectively. Half users are indoor and the other half outdoor, with 30% of the users performing data and 70% voice. This scenario uses only one BS placed in different locations, always at the buildings top, 3 m above the roof.

At least, 5 simulation runs were performed for each situation and 30 in each floor, in order to get statistical relevance. The analysis was focus in the interference behaviour. Detailed information can be found in [12].

B. Measurements

In order to evaluate the simulator, measurements in a real network were performed. The north tower of Instituto Superior Técnico (Technical University of Lisbon) was the chosen place, Fig. 1. This scenario fits the situation when BS is in LoS with the MT, since this building is higher than other neighbour buildings.

Measurement files reveal that was established connection with 5 BSs, i.e. 15 sectors as shown in Fig. 2. But only 3 sectors served the MT in all floors, the sectors with the SC 126, 232 and 217. So, the analysis was focused on these sectors.

The sectors are radiating the tower with the upper half profile of their vertical radiation pattern. In what concerns the horizontal pattern, sector 126 is radiating with the main lobe, sector 232 with the front side and sector 217 with the side profile.

After filtering the information, the results were drawn. So, for each case (0, 1 and 2 walls) an average over all sectors results was done and the standard deviation quadratic mean was calculated. In case of 2 walls the trend line is given by (18). In case of 1 wall the trend line is given by (19). In case of 0 walls the trend line is given by (20). In Fig. 3, the trend lines of the measurements results are presented.

\[
(E_b / N_0)_\text{dB}_{\text{in}} = -0.45 \times F_n + 16.08 \tag{18}
\]

\[
(E_b / N_0)_\text{dB}_{\text{in}} = -0.23 \times F_n + 14.39 \tag{19}
\]

\[
(E_b / N_0)_\text{dB}_{\text{in}} = -0.27 \times F_n + 15.43 \tag{20}
\]

In conclusion, while the MT is in the upper floor the interference is higher than in the lower floor in relation to the received power. This conclusion can be taken because in R99 \( E_b/N_0 \) relation is proportional to the SINR.

C. Measurements vs. Simulator

In order to evaluate the simulator fidelity, a scenario based on measurements environment was created. All characteristics of this simulated scenario are described in [12] in detail.

Once, the measurements results obtained are for DL, and the idea is to compare the real scenario to the simulation values, so only DL simulation results are shown.
Both real and simulated results present the same trend. Despite the different in the inference level for each case, 2 dB in average, they are within the standard deviation limits. In the simulated case, the $C/I$ relation has its best values when MT is only attenuated by 1 glass, followed by 1 wall and then 2 walls. They present a slope that is almost half of the measurements, i.e. it decreases in average 0.1 dB per floor and a difference between each case of penetrated walls is 0.5 dB. Simulations show that the measurements results for the 2 walls situation do not have the right behaviour. Although, these results reinforce the idea that the interference is higher as higher the MT is. Despite the difference in the interference level, it can be said the simulator is a powerful tool for interference analysis.

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**D. Results**

1) Reference

In this section, the results of the simulations performed for reference scenario are presented and analysed. Additional results obtained can be found in [12].

For the default scenario, the variations of the interference are presented in Fig. 5 and in Fig. 6. The interference in DL is higher than in UL. The main cause is the power transmitted by the BS being higher than the MT one. In DL, interference shows a trend to become higher as higher the MT is, because while the MT is going up on the building the path loss attenuation decrease and the MT become visible by the BS. It can be also noticed a bigger step from the 7th floor. This occurs because the model for path loss calculation is changed for one LoS model, free space or WI LoS. The number of penetration walls shows to have an impact on the interference, i.e. the interference becomes 2.9 dB lower when MT passes from the 0 walls situation to the situation of 1 wall, and when MT goes by the 2 walls situation it becomes 2.8 dB lower in relation to the situation of 1 wall. In UL, the interference shows a constant behaviour, independently of the number of penetrated walls. This happens because the number of users is almost equal in all simulations.

After analysing the Fig.5 and 6 and in order to get a better view of the interference behaviour, the interference trend lines can be drawn, as shown in Fig. 7. The DL way can be analysed in 2 perspectives: global or particular. In the global way there is only one trend. Since, in the particular way split the trend in LoS and NLoS.

Therefore, in a global view interference is given by (21). In a particular view, in case of NLoS it is given by (22) and (23) for LoS. The UL way, the inference trend line is given by (24). In Fig.7, it is only presented one to the three cases of penetrated walls situation because the difference between them is the interference level of 2.8 dB, in average.

\[
I_{(\text{dBm})} = 2.52 \times F_N - 97.29 \quad (21)
\]

\[
I_{(\text{dBm})} = 1.23 \times F_N - 93.97 \quad (22)
\]

\[
I_{(\text{dBm})} = 3.27 \times F_N - 80.05 \quad (23)
\]

\[
I_{(\text{dBm})} = -0.09 \times F_N - 111.16 \quad (24)
\]
Summarizing, in DL the interference increases by 2.52 dB per floor in a global view, and while the analysis is split by 1.23 dB and 3.27 dB in case of NLoS and LoS respectively.

2) Dependence on Distances

Taking reference the scenario in account, only the distance between MT and BS was changed in order to verify how the system reacts.

Increasing and decreasing the distance between MT and BS has an impact in one majority element: received power. As near as the BS is to the MT, the higher the MT received power, consequently the interference is higher. Therefore, with this parameters changing the interference is approximately 8 dB higher while BS is near to the MT, and it become 5 dB below the reference level when the BS is in a far position, as shown in Fig. 8. In UL, the interference does not present any relevant variation. This happen because the number of served users is practically equal during the simulation.

3) Dependence on Central Building Height

In this case, the simulations are performed for different heights of the central building. The higher central building is the reference case with 33 m of height. In case of central building with equal as neighbours, it has 21 m of height. When the central building is lower than others, it has 12 m of height. All other environment characteristics are maintained equal.

The main parameter that changes with the building height variation is the path loss attenuation, i.e. the path loss calculation is performed according LoS existence or not. So, in order to have a better analysis, the interference results were split in two ways, one while MT is in LoS and other when it is in NLoS. This parameter has a visible impact on the interference results, Fig. 9. In both cases, when the height of the central building is equal and while it is lower than other, the MT is always in NLoS with BS. So, as expected, the difference between these two cases does not exist.

In DL, in case of reference, interference presents to have the same performance as the other two cases until 7° floor, from there the slope has more 2 dB and the standard deviation gets higher in 0.5dB. While MT is among 0 and 6° floor, it is in NLoS, and from the 7° floor it becomes in LoS with BS. When there is LoS between MT and BS the path loss is lower than in case of NLoS, consequently the interference is higher in case of LoS. These are the reasons for the different behaviours.

The LoS does not have a direct influence in UL, i.e. the interference in UL depends on the number of users served. With building height variation, the number of users during the simulation is almost equal, therefore interference behaviour does not present variation.

4) Dependence on Street Width

In this test, the street widths are increased for the double and decreased for the half, i.e. in reference scenario the street has 12 m of width, it will be 24 m in the case of duplicated, and 6 m in the case of half. As in other tests all the other parameters remain equal.

As previously test, the path loss attenuation is the main parameter that suffers impact with these changes. Therefore, it is also split the analysis into two ways, one for NLoS and other for LoS.

In DL, while the MT is in NLoS, Walfish-Ikegami is the used model in the majority of the cases. So, when the streets enlarge its width the attenuation becomes lower. With the opposite being also true, i.e. when the street width is reduced the attenuation becomes higher. Interference has an inverse behaviour in relation to the path loss, i.e. when path loss increases the interference decrease.

As Fig.10 shows, when the width is duplicated the interference increases 2.42 dB and while it is reduced for half, the interference decreases 2.81 dB. The interference for the LoS case does not suffer impact with these changes because LoS models are independent of the street width.

In UL, the behaviour is almost equal, though, it can be noticed a higher interference level for \( \frac{w}{2} \). While the streets have half of its width the scenario becomes smaller, so the users are nearer the BS. Consequently, less transmitted power is required to establish connection, more users are served, the interference level increase. Despite in case of \( \frac{w}{2} \), the scenario becomes larger, the difference of interference level with the reference is approximately 0 because the number of users served is almost the same as in case of \( w \). However, the difference is positive. In case of NLoS, Walfish-Ikegami model is the reason for this because it is the model majority
used. Thus, when \( ws \) increase, the path loss decrease and the interference increase. In case of LoS, the LoS models change with the distance, if the BSs are in the same place the distance will be the same, as well as the interference.

![Graph](a) DL way, (b) UL way.

Figure 10. Dependence on street width in relation to the reference case.

5) **Dependence on Antenna Tilts**

The antenna tilt is the parameter that is changed in this test. So, simulations with 5° and 10° of down tilt were performed. The antenna with 0° of tilt corresponds to the reference.

The tilt change has a direct impact in the antenna gain. In DL, the levels of interference for -5° and -10° are better than in case of 0°. It is presented an improvement of 2 dB and 4 dB for the cases of -10° and -5° respectively, because with this tilts the BSs improves the transmitter power, i.e. for the same received power and path loss, higher gain results in a lower transmitter power, consequently lower interference. Between -5° and -10° is presented a difference of 1.65 dB, Fig. 11. The interference values for -5° are lower than for -10° because the antenna beam width is 6 dB resulting in a better performance.

In UL, the difference between 0° and -5° is almost 0, and between 0° and -10° is rounding the 2 dB. The increase on interference level reveals a growth in the number of users served.

![Graph](Figure 11. Dependence on antenna tilt in relation to the reference case.

6) **Dependence on Number of BSs**

The increase of the BSs number is the last and the more interesting test. One BS is the reference. Simulations for 2 BSs, 3 BSs and 4 BSs were the cases performed. All BSs added have the same characteristics as the reference BS.

In DL, an increasing in the BSs number results in an increasing of the interference level, because there are more BSs causing interference in the MT. In case of 2 BSs the interference in relation to reference grows 5 dB, Fig. 12. When one more BS is employed this difference increase 3 dB, i.e. it become 8 dB higher. In case of 4 BSs the interference has more 12dB in relation with 1 BS. The standard deviations suffer an increasing with the number of BSs rising.

In UL, the interference level becomes lower with the increase of the BSs number. Though, the difference between each other is not as higher as in DL. This difference happens because with more BSs, the MTs have more options to spread in the network, decreasing the interference.

In conclusion, the variation of this parameter has more impact in DL way than in UL. In DL, for each BS that is employed on the scenario the interference become approximately 4 dB higher.

![Graph](Figure 12. Dependence on number of BSs in relation to the reference case.

V. **CONCLUSIONS**

This work deals with the problem of interference in UMTS radio networks. It presents a perspective for interference prediction with the buildings height, for a uniform user’s distribution and a regular environment.

A simulator with a statistical approach has been used to implement the models. Always, the city of Lisbon was taken into account as a background scenario.

The main conclusion in DL the higher the MT is in the building, the higher the interference is. This increasing trend has a global rise of 2.5dB per floor and a difference of 2.8dB between each penetrated wall situation. This slope is different if the analysis is split, in NLoS and LoS. When the MT is in LoS the slope increases almost two times faster than when it is in NLoS. In UL the interference has a constant behaviour.

In DL the interference has its higher values when the MT is in the 0 walls situation that is near -97 dBm. The interference shows to have an increase trend. This happens because the higher the MT is, the more exposed to other sectors it is, and that increases the interference. This trend can be split in two ways, when the MT is in NLoS and LoS. Therefore, when the MT is in NLoS the interference rises 1.23 dB per floor and when it is in LoS 3.27dB. In UL the interference has an approximately constant behaviour rounding -111 dBm. This happens because the number of users that interferes is more or less equal while the MT goes up.

With the reference scenario established the parameters were changed one by one. From all parameters was antenna tilts and the number BSs that shown to have a key role in the
interference behaviour. In case of changing the antenna tilts, the interference can be improve in one way (DL/UL) and in the other way it gets worse, the parameter should be changed very carefully, trying to get a balance. The increasing of BSs number results in an increase on the interference level, seeing the MT is interfered by more BSs.

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