**3GPP TSG RAN WG1 #94 R1-180xxxx**

**Augest 20th – Augest 24th, 2018**

**Gothenburg, Sweden**

**Agenda item:** **7.6.1**

**Source: Qualcomm Incorporated**

**Title: Email discussion on NR-U outdoor sub7 GHz simulation calibration**

**Document for:** **Discussion and Decision**

# Background

In RAN1 #93, the following agreements were reached:

Agreement:

* For sub7 GHz outdoor scenario, adopting the following
  + Macro deployment with ISD=200×A meters
  + Each operator randomly drops 1 micro-layer TRP within each macro cell sector with minimum distance between micro-layer TRPs equals 57.9×A meters
  + Independent dropping between two operators
    - Use 10 meters as the inter-operator micro-layer TRP minimum distance
    - For the inter-operator micro-layer TRP maximum distance
      * Outdoor scenario 1: 30
      * Outdoor scenario 2: No limit as long as the TRP is within the macro cell
  + UE randomly dropped within macro cell sector with a minimum serving cell RSSI of -82dBm
  + All UEs dropped outdoor
  + Try A>=1 and find the A that satisfies serving cell received power distribution satisfies (10+X)% to (15+X)%] UEs below -72dBm
  + Other parameters follow the table below

|  |  |
| --- | --- |
| Parameters | Outdoor Sub-7GHz |
| Carrier Frequency | 5GHz |
| Carrier Channel Bandwidth | 20MHz baseline , 80MHz optional |
| Number of carriers | 1 |
| Number of users per operator | 5 per gNB per 20MHz |
| SCS | To be reported together simulation results |
| Channel Model | NR UMi street canyon |
| BS/AP Tx Power | 23dBm (total across all TX antennas) |
| UE/STA Tx Power | 18dBm (total across all TX antennas) |
| BS/AP Antenna gain | 0 dBi |
| UE/STA Antenna gain | 0 dBi |
| BS/AP Noise Figure | 5dB |
| UE/STA Receiver Noise Figure | 9dB |
| Minimum received power from serving cell for UE dropping | -82dBm |
| UE receiver | MMSE-IRC as the baseline receiver |
| BS/AP antenna Array configuration | (M, N, P, Mg, Ng) = (1, 2, 2, 1, 1), dH = dV = 0.5 λ |
| UE/STA antenna Array configuration | Baseline Tx/Rx: (M, N, P, Mg, Ng) = (1, 1, 2, 1, 1), dH = dV = 0.5 λ  Optional Tx/Rx: (M, N, P, Mg, Ng) = (1, 2, 2, 1, 1), dH = dV = 0.5 λ |
| Traffic model | Use 36.889 Table A.1.1.  Note: Results based on the mixed traffic models can be used to determine the design. |
| UE/STA to UE/STA link pathloss model | Directly use UMi street canyon pathloss model with proper d\_3D with UMi street canyon LOS probability |
| gNB to gNB link pathloss model | Directly use UMi street canyon pathloss model with proper d\_3D with UMi street canyon LOS probability |

An email discussion was assigned to further fine tune the parameters (A and X) on the layout of the simulation, targeting Augest 2nd for a decision. The email discussion is organized into two steps:

* Step 1: Generating the necessary cdfs
  + Target a deadline of 6/15/18
  + Companies to provide serving cell received power cdf for a sweep of A parameters for each sub-scenario
  + We will send out a word document and excel sheet in a few days like what we did for the indoor calibration.
* Step 2: Further discussion on agreeing on the X value and selecting an A parameter
  + Target an agreement on 8/2/18

This paper summarizes the email discussion Discussions. A companion spreadsheet contains the raw data for the cdf curves provided by different companies.

# Step 1 calibration

Following the agreed parameters as below, we sweep A=1, 1.2, 1.4, 1.6, 1.8, and 2. In these simulations, UE redropping with -82dBm is applied as well.

* Macro deployment with ISD=200×A meters
* Each operator randomly drops 1 micro-layer TRP within each macro cell sector with minimum distance between micro-layer TRPs equals 57.9×A meters
* Independent dropping between two operators
  + Use 10 meters as the inter-operator micro-layer TRP minimum distance
  + For the inter-operator micro-layer TRP maximum distance
    - Outdoor scenario 1: 30
    - Outdoor scenario 2: No limit as long as the TRP is within the macro cell
* UE randomly dropped within macro cell sector with a minimum serving cell RSSI of -82dBm
* All UEs dropped outdoor

12 companies provided calibration results for serving cell RSSI distribution for scenario 1 and scenario 2. The following figures show the cdf of UE received signal power from serving cell for scenario 1 and scenario 2. Note that for the UE serving cell received power cdf, the difference between scenario 1 and scenario 2 is not obvious.



Figure 1. UE serving cell received power cdf, A=1, Scenario 1



Figure 2. UE serving cell received power cdf, A=1.2, Scenario 1



Figure 3. UE serving cell received power cdf, A=1.4, Scenario 1



Figure 4. UE serving cell received power cdf, A=1.6, Scenario 1



Figure 5. UE serving cell received power cdf, A=1.8, Scenario 1



Figure 6. UE serving cell received power cdf, A=2, Scenario 1



Figure 7. UE serving cell received power cdf, A=1, Scenario 2



Figure 8. UE serving cell received power cdf, A=1.2, Scenario 2



Figure 9. UE serving cell received power cdf, A=1.4, Scenario 2



Figure 10. UE serving cell received power cdf, A=1.6, Scenario 2



Figure 11. UE serving cell received power cdf, A=1.8, Scenario 2



Figure 12. UE serving cell received power cdf, A=2, Scenario 2

The percentile at -72dBm for each layout options are summarized in the next table.

Table 1. Percentile of -72dBm point for UE serving cell received power for scenario 1

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **A=1.0** | **A=1.2** | **A=1.4** | **A=1.6** | **A=1.8** | **A=2.0** | **A=3.0** |
| Qualcomm | 5.4% | 12.7% | 19.2% | 25.6% | 30.2% | 34.8% |  |
| Intel | 3.4% | 10.8% | 17.2% | 25.7% | 30.3% | 37.0% | 47.9% |
| LG | 5.8% | 12.6% | 20.3% | 27.5% | 33.3% | 37.7% |  |
| InterDigital | 4.4% | 9.4% | 18% | 24.5% | 32.7% | 35.9% |  |
| Ericsson | 3.3% | 9.5% | 16.9% | 24.7% | 32% | 36.3% |  |
| MediaTek | 4.2% | 12.0% | 17.2% | 24.7% | 31.7% | 36.5% |  |
| ZTE | 4.2% | 10.3% | 17.8% | 26.6% | 32.5% | 36.3% |  |
| Samsung | 5.8% | 12.5% | 19.1% | 25.4% | 31.1% | 36.8% |  |
| Nokia | 7.0% | 14.8% | 21.2% | 27.9 | 33.2% | 38.2% |  |
| Broadcom | 8.1% | 13.5% | 17.9% | 22.3% | 27.4% | 30.8% |  |
| vivo | 3.6% | 9.1% | 17.8% | 24.2% | 36.1% | 39.1% |  |
| Huawei | 7.4% | 14.3% | 21.9% | 28.4% | 33.4% | 37.8% |  |
| Average | 5.16% | 11.81% | 18.48% | 25.49% | 31.44% | 36.03% |  |

Table 2. Percentile of -72dBm point for UE serving cell received power for scenario 2

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **A=1.0** | **A=1.2** | **A=1.4** | **A=1.6** | **A=1.8** | **A=2.0** | **A=3.0** |
| Qualcomm | 6.1% | 13.1% | 18.9% | 24.3% | 28.6% | 36.2% |  |
| Intel | 4.4% | 9.4% | 17.4% | 25.4% | 32.1% | 36.7% | 50.8% |
| LG | 5.8% | 12.7% | 19.9% | 27.3% | 33.1% | 37.3% |  |
| InterDigital | 3.8% | 9.8% | 18.1% | 24.4% | 32.3% | 35.4% |  |
| Ericsson | 3.6% | 9.3% | 16.7% | 24.6% | 32.2% | 36.3% |  |
| MediaTek | 2.9% | 9.4% | 18.6% | 25.0% | 30.3% | 39.1% |  |
| ZTE | 4.6% | 9.5% | 18.2% | 25.4% | 30.5% | 36.9% |  |
| Samsung | 5.7% | 11.8% | 19.1% | 25.3% | 30.9% | 37.7% |  |
| Nokia | 7.4% | 14.6% | 21.3 | 28.2% | 32.8% | 37.9 |  |
| Broadcom | 8.4% | 13.1% | 18.5% | 23.2% | 26.5% | 29.5% |  |
| vivo | 4.1% | 10.7% | 19.5% | 27.4% | 35.8% | 37.1% |  |
| Huawei | 7.2% | 14.6% | 22.5% | 28.5% | 33.5% | 38.8% |  |
| Average | 5.27% | 11.27% | 18.67% | 25.31% | 30.93% | 36.30% |  |

In each table, the average across all companies results are also provided in the last row, and plotted in the figure below.

Figure 13. Average % of UE below -72dBm as a function of “A”

Between scenario 1 and scenario 2, due to different ways to drop gNBs between the operators, the max AP2AP received power cdf will be different. This is not an agreed calibration metric and the results are optionslly provided by five companies for reference. The average results across all companies are provided in the last row of the tables as well.

Table 3. Percentile of -72dBm point for Max AP2AP received power for scenario 1

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **A=1.0** | **A=1.2** | **A=1.4** | **A=1.6** | **A=1.8** | **A=2.0** |
| Qualcomm | 0% | 0.1% | 0.1% | 0.4% | 0.6% | 0.8% |
| LG | 0% | 0.1% | 0.2% | 0.3% | 0.2% | 0.4% |
| InterDigital | 0% | 0.1% | 0% | 0% | 0.5% | 0.2% |
| Nokia | 0% | 0.1% | 0.1% | 0.3% | 0.3% | 0.4% |
| Broadcom | 0% | 0% | 0% | 0.2% | 0.4% | 0.4% |
| Average | 0.00% | 0.08% | 0.08% | 0.24% | 0.40% | 0.44% |

Table 4. Percentile of -72dBm point for Max AP2AP received power for scenario 2

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **A=1.0** | **A=1.2** | **A=1.4** | **A=1.6** | **A=1.8** | **A=2.0** |
| Qualcomm | 0.8% | 2.7% | 7.3% | 16.5% | 23% | 32% |
| LG | 1.1% | 3.8% | 9.7% | 16.8% | 25.7% | 33.7% |
| InterDigital | 0.4% | 1.5% | 5.9% | 13% | 21.3% | 30.5% |
| Nokia | 2.5% | 6.3% | 12.7% | 21.8% | 29.6% | 37.2% |
| Broadcom | 0.2% | 2% | 6.6% | 13.6% | 21.4% | 29.8% |
| Average | 1.00% | 3.26% | 8.44% | 16.34% | 24.20% | 32.64% |

Figure 14. Average maximum AP2AP link below -72dBm as a function of “A”

Table 5. Company observations

|  |  |
| --- | --- |
| Company | Comments |
| Qualcomm | As expected, with larger A, the UE RSSI will be lower. For both scenarios, with A=1.2, we can achieve below -72dBm within 10~15%, and with A=1.5, we can achieve below -72dBm within 20~25%. Between secnarios, the max AP2AP received power distribution is different. For scenario 1, as the APs are dropped within the hopspot, the max AP2AP is always high, and almost 0% max AP2AP links are below -72dBm. For scenario 2, the max AP2AP is lower. |
| Intel | Both scenario 1 and scenario 2 provide very similar results in terms of the serving link RSRP distribution with negligible differences for each value of A. While A=2.0 achieves about 35-40% of serving link RSRP to be below -72dBm, we have also provided results for A=3.0 in consideration of the measured RSRP value range provided in R1-1807327 for an outdoor Wi-Fi network. The AP2AP RSRP statistics are not provided as they are out of the scope for this email discussion. |
| LG | For A = 1, it is observed that the percentile of UE’s received power below -72 dBm is smaller than 10% (i.e., about 6%) in both scenarios. As expected, we can observe as the value of A increases, the percentile of UEs below -72 dBm also increases. Especially for A=1.2 and 1.6, it is observed that the percentile of UE’s received power below -72 dBm is about 12% and 27%, respectively. |
| InterDigital | Results for both scenarios are provided which indicate increasing percentage of RSSI<-72dBm with increasing value of A. A value of 1.2<A<1.4 would give the desired percentage of %10-%15. |
| Ericsson | It is observed that the results for both scenarios are quite similar in terms of serving link RSSI for different A values. With larger A value, weak UE RSSI ratio becomes higher as expected: with A=1.3-1.4, RSSI below -72dBm may achieve 10%-15%; with A=1.5-1.6, RSSI below -72dBm may achieve 20%-25%. The AP2AP RSRP statistics are not provided as they are out of the scope for this email discussion. |
| MediaTek | First, the distributions of serving cell received power in scenario 1 and scenario 2 are similar for each value of A. Second, with A= 1, the ratio of UEs with serving cell received power below -72dBm is smaller than 10%. Thus, the value of A should be increased. With A = 1.2, it has 10%~15% UEs with serving cell received power below -72dBm. With A = 1.4, it has 15%~20% UEs with serving cell received power below -72dBm. With A = 1.6, it has 20%~25% UEs with serving cell received power below -72dBm. Third, we did not provide the results of AP2AP links since it is out of scope in this email discussion. |
| ZTE | As observed, for both scenarios we can achieve (10+X)% to (15+X)%   of serving link RSRP below -72dBm, when A is greater than 1.2, assuming X is positive. Especially for A=1.4,we can achieve below -72dBm within 15~20%, and for A=2.0, we can achieve below -72dBm within 35~40%. |
| Samsung | The serving link received power distribution is very similar for both scenarios with only minor differences. It can be observed that 10% to 15% of serving link received power below -72 dBm can be achieced with A = 1.2 for both scenarios. In addition, more fraction of serving links below -72 dBm will be observed with higher value of A. |
| Nokia | As also observed by other companies, for gNB-UE serving cell RSSI, there is no significant difference between the scenarios. A=1.2 appear to be a good choise for scaling factor. |
| Broadcom | As expected Scenario1 and Scenario2 have the same serving gNB-UE RSSI cdfs and very different AP2AP RSSI cdfs. In Scenario1, the AP2AP cdf is not correlated to the serving gNB-UE cdf; for example the AP2AP RSSI remains high even when the serving gNB-UE cdf is progressively made lower with increasing values of A. In Scenario2, the AP2AP cdf is correlated to the serving gNB-UE cdf. |
| vivo | From the simulation results we can see that, when A=1.2, the percentage of UE serving cell received power below -72 dBm is around 10% , and for A=1.4, it is around 18%~19%. Therefore, it can be expected that when 1.2 <A< 1.4 , the percentage of UE serving cell received power below -72 dBm is around 10%~15%. |
| Huawei, Hisilcon | Both outdoor scenario 1 and scenario 2 had similar CDF from the perspective of serving link RSSI. The percentages of serving links with RSSI below -72dBm are 7.x% and 14.x% when A=1 and 1.2 respectively. |

To summarize, the submitted results form all companies are reasonably close. Between scenario 1 and scenario 2, all companies observe the difference is small for UE serving cell RSSI distribution. As expected, the percentage of UE with serving cell RSSI below -72dBm increases with larger site-to-site distance. According average results from all companies, we need A=1.2 to reach 10%~15% UEs under -72dBm and we need A=1.5 (interpolated from A=1.4 and A=1.6) to reach 20%~25% UEs under -72dBm.

For AP2AP RSSI cdf, five companies provided results. As expected, for scenario 1, close to 0% maximum AP2AP links are below -72dBm as the APs from two operators are dropped close to hot-spot centerl. For scenario 2, the percentage of maximum AP2AP links below -72dBm increases as site-to-site distance increases.

**Observation: UE serving cell RSSI cdf is well calibration across companies. We need A=1.2 to reach 10%~15% UEs under -72dBm and we need A=1.5 to reach 20%~25% UEs under -72dBm.**

# Step 2 Calibration

For this step of the calibration, we need to agree on the target percentage of UEs with serving cell RSSI below -72dBm to select “A” parameter. Since 10%~15% and 20%~25% are the ranges of interest raised during the last meeting, we recommend to consider A=1.2 (which will achieve 10%~15%) and A=1.5 (which will achieve 20%~25%).

Table 6. Company comments

|  |  |
| --- | --- |
| Company | Comments |
| Qualcomm | Since we already agree to simulate 2 scenarios for sub7 outdoor case, it might be good to take advange of that to cover more use cases. From AP2AP RSSI distribution result, with larger A, the scenario 2 may have less AP2AP interference, while scenario 1 will not have different AP2AP interference level. Therefore we recommend to use A=1.2 for scenario 1 and A=1.5 for scenario 2. |

# Conclusion