**3****GPP TSG RAN WG1 #106b-e R1-xxxxxx**

**e-Meeting, October 11th – 19th**

**Agenda item:** **8.14.1**

**Title: [DRAFT] Observations for XR coverage evaluations in TR**

**Source: Moderator (Qualcomm)**

**Document for: Discussion**

This document is to collect comments from companies regarding observations for XR coverage evaluation based on contributions under AI 8.14.1.

# XR Coverage Evaluation

## Coverage based on Methodology 1

### FR1

#### DU

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Deployment environment | Link | Applications | PDB (ms) | # of UEs / cell | XR Coverage | | source |
| Mean (dB) | Data (dB) |
| FR1, DU | DL | VR/AR30 | 10 | 9 (Capacity?) | [-121.9] | [-121.9] | vivo |
| VR/AR30 | 10 | 8 (Capacity) | [-126] | [-126] | Nokia |
| VR/AR30 | 10 | 1 | [-120.9] | [-118.7, -123] | Vivo, Nokia |
| VR/AR45 | 10 | 6 (Capacity for 45Mbit/s) | [-126] | [-126] | Nokia |
| CG30 | 15 | 1 | [-126] | [-126] | Nokia |
| UL | AR 1 stream / scene | 30 | 9 (Capacity?) | [-117] | [-117] | vivo |
| AR 1 stream | 30 | 1 | [-118.7] | [-118.7] | vivo |

**Source Specific Observation**

* In Coverage Eval Method 1, FR1, DU, **AR30**, the DL coverage is [better] than that of UL by up to [4.9]dB.

1. **Please provide your comment on the above observations.**

|  |  |
| --- | --- |
| Company | Comment |
| Futurewei | It is expected that for B=1 the DL and UL coverage for such case is the same and can simply be derived simply from coupling gain CDF for all UEs. Furthermore, it is strange that B=1 shows better coverage than B=1 for DL. Need some explanation. |
| Huawei, HiSilicon | The observation might only be suitable for B = capacity. For B = 1, DL coverage is the same as that of UL. |
| LGE | The Observation and the results in the Table are not consistent. Please check. |
| Nokia, NSB | Some missing results have been added to the table. We also tend to share Futurewei’s concern here that DL and UL results should intuitively be much closer to each other if not identical. What are the main reasons for these 3-5 dB deviations between UL and DL? |
| Ericsson | We do not see the relevance of comparing UL and DL coverage, just as there is little point in comparing UL and DL capacity.  Evaluating coverage for DU seems less relevant: all UEs will be satisfied. |

#### UMa

Table 111 XR Coverage FR1, UMa

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Deployment environment | Link | Applications | PDB (ms) | # of UEs / cell | XR Coverage | | source |
| Mean (dB) | Data (dB) |
| FR1, UMa | DL | CG30 | 15 | Capacity | [-134.38] | [-134.38] | HW |
| 1 | [-141.595] | [-146, -137.19] | HW, Ericsson |
| VR/AR30 | 10 | Capacity | [-132.86] | [-132.86] | HW |
| 1 | [-139.5] | [-141, -140.9, -139, -137.19] | HW, vivo, Ericsson |
| VR/AR45 | 10 | Capacity | [-132.95] | [-132.95] | HW |
| 1 | [-136.58] | [-136.58] | HW |
| UL | Pose | 10 | 1 | [-132.5] | [-136.01, -129] | HW, Ericsson |
| AR 1 stream / scene | 30 | 1 | [-122.90] | [-124.2, -121.61] | HW, vivo, Ericsson |

**General Observation**

* In Coverage Eval Method 1, FR1, DU, **CG30**, the DL coverage is [better] than that of UL by up to [9]dB when B=1.
* In Coverage Eval Method 1, FR1, DU, **VR30**, the DL coverage is [better] than that of UL by up to [7]dB when B=1.
* In Coverage Eval Method 1, FR1, DU, **AR30**, the DL coverage is [better] than that of UL by up to [16.6]dB when B=1.
* In Coverage Eval Method 1, FR1, DU, **AR45**, the DL coverage is [better] than that of UL by up to [13.68]dB when B=1.

**General Observation**

* In Coverage Eval Method 1, FR1, UMa has [better] coverage than DU for the same application.

#### InH

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Deployment environment | Link | Applications | PDB (ms) | # of UEs / cell | XR Coverage | | source |
| Mean (dB) | Data (dB) |
| FR1, InH | DL | CG30 | 15 | 5 (Capacity) | [-71] | [-71] | Nokia |
| VR/AR30 | 10 | 5 (Capacity) | [-71] | [-71] | Nokia |
| CG30 | 15 | 1 | [-72] | [-72] | Nokia |
| VR/AR30 | 10 | 1 | [-72] | [-72] | Nokia |

1. **Please provide your comment on the above observations.**

|  |  |
| --- | --- |
| Company | Comment |
| Futurewei | For the first set of observation, it should be for UMa. For the second set of observation, can we really say Uma has **better** coverage than DU? What does it really mean? It is simply an artifact of this methodology as we pointed out before. Methodology 1 is flawed. |
| Huawei, HiSilicon | The first set of observations are for UMa.  The second set of observation may not be suitable, since the results for DU and UMa are from different sources. No such observation can be observed. |
| LGE | We are not sure if this can be general observation if only one result for DU is available for comparison. |
| Nokia, NSB | Added the missing results for InH FR1 (Methodology 1) as “Section 1.1.1.3. InH”  Regarding FW’s comment “*For the second set of observation, can we really say Uma has* ***better*** *coverage than DU? What does it really mean? It is simply an artifact of this methodology as we pointed out before. Methodology 1 is flawed.*”  This may be true, but do you mind clarifying, as a very similar observation is drawn below for Methodology 2 in 1.2.1.2  “o UMa has [better] coverage than DU due to higher tx power (5dB).”  What is the difference between the methodologies in this respect (i.o.w., is Methodology 2 also flawed)? |
| Ericsson | We do not see the relevance in comparing UL and DL coverage – these are different services.  It is not relevant to compute results if all UEs are satisfied – then it’s simply the pathgain CDF that we are sampling. |

### FR2

#### DU

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Deployment environment | Link | Applications | PDB (ms) | # of UEs / cell, B | XR Coverage | | source |
| Mean (dB) | Data (dB) |
| FR2, DU | DL | CG8 | 15 | 30 | [-100] |  | QC |
| VR/AR30 | 10 | Capacity | [-106.65] | [-108.8, -104.5] | QC, vivo |
| 1 | [-106.9] | [-106.9] | vivo |
| UL | Pose | 10 | 10 | [-105.2] | [-105.2] | QC |
| AR 1 stream / scene | 30 | Capacity | [-103.35] | [-104.8, -101.9] | QC, vivo |
| 1 | [-106.9] | [-106.9] | vivo |

**General Observation**

* In Coverage Eval Method 1, FR2, DU, **CG8**, B=30, the UL coverage is [better] than that of DL by up to [5.2]dB when B=Capacity
* In Coverage Eval Method 1, FR2, DU, **VR30**, B=Capacity, the DL coverage is [better] than that of UL by up to [1.45]dB when B=Capacity.
* In Coverage Eval Method 1, FR2, DU, **AR30**, the DL coverage is [better] than that of UL by up to [3.3]dB when B=Capacity.
* In Coverage Eval Method 1, FR2, DU, **AR30**, the DL coverage is similar with that of UL when B=1.

1. **Please provide your comment on the above observations.**

|  |  |
| --- | --- |
| Company | Comment |
| Futurewei | When comparing the DL and UL results, the B value should be the same for DL and UL simulation. Otherwise, the comparison is not meaningful. So please the companies specify the values of B. |
| Huawei, HiSilicon | Suggest red changes:   * In Coverage Eval Method 1, FR2, DU, **CG8**, ~~B=30,~~ the UL coverage is [better] than that of DL by up to [5.2]dB when B=Capacity * In Coverage Eval Method 1, FR2, DU, **VR30**, ~~B=Capacity,~~ the DL coverage is [better] than that of UL by up to [1.45]dB when B=Capacity. |
| LGE | It seems that the comparison is being made based on the mean value. Then the observation should be “on average” or “around” rather than “up to”. Or instead, we could think of putting a range of values rather than the average or maximum value to get the information on the minimum as well.  Some of the observations above are source-specific rather than general. Maybe okay if we get more results in the future.  Should we assume that B=30=capacity for DL CG8 and B=10=capacity for UL Pose? It seems so based on the observations above, but not clear in the Table. |
| Ericsson | No point in comparing UL and DL. |

#### InH

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Deployment environment | Link | Applications | PDB (ms) | # of UEs / cell | XR Coverage (dB) | | source |
| Mean (dB) | Data |
| FR2, DU | DL | CG8 | 15 | 30 | [-85.4] | [-85.4] | QC |
| VR/AR30 | 10 | Capacity | [-84.8] | [-86.5, -82.9] | QC, vivo |
| 1 | [-85] | [-85] | vivo |
| UL | Pose | 10 | 25 | [-90.5] | [-90.5] | QC |
| AR 1 stream / scene | 30 | Capacity | [-82.55] | [-85, -80.1] | vivo, QC |
| 1 | [-85] | [-85] | vivo |

**General Observation**

* In Coverage Eval Method 1, FR2, InH, **CG8**, B=Capacity, the UL coverage is [better] than that of DL by up to around [5.1]dB.
* In Coverage Eval Method 1, FR2, InH, **VR30**, B=Capacity, the UL coverage is [better] than that of DL by up to [5.8]dB.
* In Coverage Eval Method 1, FR2, InH, **AR30**, the DL coverage is [better] than that of UL by up to [2.15]dB.

**General Observation**

* Coverage Evaluation Methodology 1 in FR1 and FR2:
  + The coverage evaluated in capacity regime (B=Capacity) is in general worse than the coverage measured with B=1.

1. **Please provide your comment on the above observations.**

|  |  |
| --- | --- |
| Company | Comment |
| Futurewei | When comparing the DL and UL results, the B value should be the same for DL and UL simulation. Otherwise, the comparison is not meaningful. So please the companies specify the values of B. |
| LGE | Similar comments as above.  It seems that the comparison is being made based on the mean value. Then the observation should be “on average” rather than “up to”. Apart from that, we prefer the values to be a range rather than on the maximum to get the information on the minimum as well.  Some of the observations above are source-specific rather than general. Maybe okay if we get more results in the future.  Should we assume that B=30=capacity for DL CG8 and B=25=capacity for UL Pose? It seems so based on the observations above, but not clear in the Table. |
| Ericsson | Hardly possible to assess service coverage from an InH simulation. |

## Coverage based on Methodology 2

In methodology 2, we evaluate XR coverage with 1 UE per network.

### FR1

#### DU

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Deployment environment | Link | Applications | PDB (ms) | XR Coverage | | source |
| Mean (dB) | Data (dB) |
| FR1, DU | DL | CG30 | 15 | [-138.45] | [-141.4, -135.5] | QC, Intel |
| VR/AR30 | 10 | [-138.93] | [-144.58, -137.4 -134.80] | vivo, QC, Intel |
| UL | Pose | 10 | [-137.47] | [-140.3, -134.6] | QC, Intel |
| AR 1 stream / scene | 30 | [-126.84] | [-126.84] | vivo |
| AR 2 streams | 10,30 | [-119.9] | [-119.9] | QC |

**General Observation**

* In Coverage Eval Method 2, FR1, DU, **CG30**, the DL coverage is [better] than that of UL by up to around [0.98]dB.
* In Coverage Eval Method 2, FR1, DU, **VR30**, the DL coverage is [better] than that of UL by up to [1.07]dB.
* In Coverage Eval Method 2, FR1, DU, **AR30**, the DL coverage is [better] than that of UL by up to [18.64]dB.

1. **Please provide your comment on the above observations.**

|  |  |
| --- | --- |
| Company | Comment |
|  |  |
|  |  |
|  |  |

#### UMa

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Deployment environment | Link | Applications | PDB (ms) | XR Coverage (dB) Mean, Range | source |
| FR1, UMa | DL | CG30 | 15 | [-147.16, (-148.2, -146.4)] | HW, Intel, QC |
| VR/AR30 | 10 | [-144.67, (-150.07, -141.6)] | HW, vivo, Intel, QC |
| VR/AR45 | 10 | [-143.85] | HW |
| UL | Pose | 10 | [-139.73, (-140.5, -137.81)] | HW, Intel, QC |
| AR 1 stream / scene | 30 | [-124.48, (-126.39, -122.57)] | HW, vivo |
| AR 2 stream | 10,30 | [-121.7] | QC |

**General Observation**

* In Coverage Eval Method 2, FR1, UMa, **CG30**, the DL coverage is [better] than that of UL by up to around [7.43]dB.
* In Coverage Eval Method 2, FR1, UMa, **VR30**, the DL coverage is [better] than that of UL by up to [4.93]dB.
* In Coverage Eval Method 2, FR1, UMa, **AR30**, the DL coverage is [better] than that of UL by up to [22.15]dB.

**General Observation**

* For Coverage Evaluation Methodology 2 in FR1;
  + In DU/UMa, DL coverage is [better] than UL coverage, which indicates that [UL] is ***bottleneck***.
  + Applications with relaxed requirements (e.g., lower data rate, larger PDB) has larger coverage.
  + UMa has [better] coverage than DU due to higher tx power (5dB).
  + UMa and DU have similar UL coverage.
  + UL Pose has [1~7]dB [worse] coverage than CG30 DL.
  + UL Pose has [1~5]dB [worse] coverage than VR30 DL.
  + AR UL has [18~ 22]dB [worse] coverage than AR30 DL.

1. **Please provide your comment on the above observations.**

|  |  |
| --- | --- |
| Company | Comment |
| Huawei, HiSilicon | For the second set of observations,  Sub-bullet#3 is only correct for DL.  Sub-bullet#3 and #4 are from different sources. Companies may have different simulation setups.  Sub-bullet#5~#7 are already captured in the first set of observations. No need to capture again. |
| LGE | What the parenthesis in the square bracket means in the table above is not clear.  Also, the number of companies and the number of results do not match in the 2nd and 5th row. |
| Nokia, NSB | * + UMa has [better] coverage than DU due to higher tx power (5dB).   Is the impact of Tx power really that high here if the coverage metric is focused on the coupling gain (power ratio)? |

### FR2

#### DU

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Deployment environment | Link | Applications | PDB (ms) | XR Coverage (dB) Mean, Range | # of data points |
| FR2, DU | DL | AR30 | 10 | -127.66 | 1 (vivo) |
| UL | AR 1 stream / scene | 30 | -120.17 | 1 (vivo) |

**General Observation**

* In Coverage Eval Method 2, FR2, DU, **AR30**, the DL coverage is [better] than that of UL by up to around [7.51]dB.

**General Observation**

* In Coverage Eval Method 2, DU, AR30 DL, the DL coverage of FR1 is [better] than that of FR2 by up to [10.88]dB.
* In Coverage Eval Method 2, DU, AR30 UL, the UL coverage of FR1 is [better] than that of FR2 by up to [6.67]dB.

1. **Please provide your comment on the above observations.**

|  |  |
| --- | --- |
| Company | Comment |
| Huawei, HiSilicon | For the first set of observations, source specific observation might be better, since there is only one source.  For the second set of observations, comparison between FR1 and FR2 may not be proper, since they may have different sources and thus different simulation setups. |
|  |  |
|  |  |

#### InH

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Deployment environment | Link | Applications | PDB (ms) | XR Coverage (dB) Mean, Range | # of data points |
| FR2, InH | DL | AR30 | 10 | -102.67 | 1 (vivo) |
| UL | AR 1 stream / scene | 30 | -108.17 | 1 (vivo) |

**Source Specific Observation**

* In Coverage Eval Method 2, FR2, InH, **AR30**, the UL coverage is [better] than that of DL by up to around [5.5]dB.

**Source Specific Observation**

* The coverage of Coverage Evaluation Methodology 1 (w/ B=1) is in general smaller than that measured based on Evaluation Methodology 2 for the same case.

1. **Please provide your comment on the above observations.**

|  |  |
| --- | --- |
| Company | Comment |
| Futurewei | Comparing methodology 1 and 2 is interesting though we all knew this even before doing simulation as methodology 1 included inter-cell interference and hence does not really give conventional coverage result. |
| Huawei, HiSilicon | For the second set of observations, the observation is somehow reasonable, since methodology 1 includes inter-cell interference and hence the results can be smaller than that measured based on methodology 2. However, comparison between different methodologies may not be needed. Just capturing the results of both methodologies is enough. |
|  |  |