3GPP TSG RAN WG1 #103-e R1-20xxxxx

e-Meeting, October 26th – November 13th, 2020

Source: Moderator (vivo)

Title: Email discussion approval for applications, traffic model and evaluation methodology: Capacity evaluation

Agenda Item: 8.14.1

Document for: Discussion and Decision

# Introduction

This contribution is a summary on the capacity considerations for XR and Cloud Gaming in the contributions [1-18] submitted under AI 8.14.1. The AI is related to applications, traffic model and evaluation methodology as the following objectives of the study item on XR evaluation for NR:

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| 1. Confirm XR and Cloud Gaming applications of interest 2. Identify the traffic model for each application of interest taking outcome of SA WG4 work as input, including considering different upper layer assumptions, e.g. rendering latency, codec compression capability etc. 3. Identify evaluation methodology to assess XR and CG performance along with identification of KPIs of interest for relevant deployment scenarios 4. Once traffic model and evaluation methodologies are agreed, carry out performance evaluations towards characterization of identified KPIs |

# Capacity for XR

## Deployment

Use cases and deployment scenarios of XR/CG applications proposed by companies [2][3][4][8][11][12][13][15][18] are summarized as below.

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| **Companies/scenarios** | **VR** | **AR** | **Cloud gaming** |
| **Huawei** | Dense urban  Urban Macro | Dense urban  Urban Macro | Dense urban  Urban Macro |
| **vivo** | Indoor hotspot  Dense urban | Indoor hotspot  Dense urban | Indoor hotspot  Dense urban |
| **CATT** | Indoor hotspot  Dense urban | Indoor hotspot  Dense urban | Indoor hotspot  Dense urban |
| **LG** | Indoor with low mobility | AR1: Indoor/outdoor with low mobility  AR2: Indoor/outdoor with low/high mobility | Indoor/outdoor with low/high mobility |
| **MediaTek** | Indoor hotspot (FR1/FR2) | AR1: UMi(indoor & outdoor) (FR1/FR2), HST(FR1)  AR2: UMi(indoor & outdoor) (FR1/FR2) | UMi(indoor & outdoor) (FR1)  Rural(indoor & outdoor) (FR1)  High speed train (FR1) |
| **Xiaomi** |  | Indoor/outdoor (FR1/FR2) | Indoor/outdoor (FR1/FR2) |
| **Qualcomm** | Indoor hotspot (open office) (FR1/FR2)  UMi mixed (FR1) | UMi mixed (FR1)  Indoor hotspot (open office) (FR1/FR2)  UMi (outdoor) (FR2) | UMi mixed (FR1)  Indoor hotspot (open office) (FR1/FR2)  UMi (outdoor) (FR2) |
| **AT&T** | UMa(indoor &outdoor) (FR1)  UMi(outdoor) (FR2)  Indoor hotspot (FR1/FR2) | UMa(indoor & outdoor) (FR1)  UMi(outdoor) (FR2)  Indoor hotspot (FR1/FR2) | UMa(indoor & outdoor) (FR1)  UMi(outdoor) (FR2)  Indoor hotspot (FR1/FR2) |
| **Nokia** | Indoor hotspot  Urban Macro (UMa) | Indoor hotspot  Urban Macro (UMa) | Indoor hotspot  Urban Macro (UMa) |

The use cases of XR and CG applications can occur in the indoor or outdoor scenarios. Based on the contributions from companies, the deployment scenarios proposed include InH, UMi, Dense Urban and UMa.

**Q1: For UMi and Dense urban scenarios, whether both of them need to be separately evaluated, or only UMi is to be evaluated for the sake of reducing the number of evaluation scenarios?**

**Please share your views on Q1.**

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**Q2: The deployment scenarios for evaluation may be applied to each of XR/CG applications of interest. However, if all the XR/CG applications are considered, there will be too many combinations of deployment scenarios and XR/CG applications, which could lead to numerous simulation work. Therefore, it may be desirable to consider prioritization of combinations of deployment scenarios and XR/CG applications, e.g.,**

* **FR 1:**
  + **InH: CG and VR are prioritized.**
  + **UMi: AR and CG are prioritized.**
  + **UMa: AR (e.g., low rate AR)**
* **FR 2:**
  + **InH: CG and VR are prioritized.**
  + **UMi: AR and CG are prioritized.**
  + **UMa: N/A**

**Please note that with such prioritization, companies can still submit evaluation results for de-prioritized scenarios.**

**Please share your views on Q2 including whether such prioritization is needed or not.**

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## Evaluation methodology and assumptions

### Methodology

For evaluation of XR/CG applications, the definition of system capacity needs to be determined. In general, similar to the previous 3GPP study e.g. URLLC, the system capacity is defined as the maximum number of users per cell satisfying a certain set of requirements. Hence, for XR/CG evaluation, the system capacity can be defined as the following.

**Q3: System capacity is defined as the maximum number of users per cell with at least X % of UEs being satisfied (i.e., meeting a set of requirements). The exact requirements will be defined separately.**

**Please share your views on Q3. Companies can also present other definition of system capacity that they believe is appropriate.**

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**Q4: For the system capacity definition in Q3, the X value needs to be determined, e.g., X=90. In addition, it may be useful to collect results (i.e., # UEs per cell being satisfied or meeting the requirements) for multiple values of X, e.g., X = 70, 80, 90, 95 to see the trend of # UEs per cell meeting the requirements as the number of UEs per cell increases.**

**Please share your views on Q4.**

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**Q5: For the system capacity definition, how to determine whether a UE is satisfied or not is to be deferred until the exact traffic model along with how to measure E2E user experience is available.**

**Please share your comment on Q5.**

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**Q6: On the XR/CG evaluation, other performance metrics (in addition to # of UEs per cell being satisfied) can be reported, e.g.,**

* **PER (file dropping rate)**
* **UPT**
* **File transfer delay**
* **RU**
* **Spectrum efficiency**
* **Etc.**

**Please share your comments on Q6. Please feel free to suggest additional metrics that you believe are useful to collect.**

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It is proposed in [18] that XR capacity could highly depend on the arrival time offset of XR traffics among UEs. It may be useful to study XR capacity under various assumptions on traffic arrival offset among UEs.

**Q7: Whether and how to evaluate XR capacity under various assumptions on traffic arrival offset among UEs (e.g., random offsets, uniform offsets)?**

**Please share your comments on the Q7.**

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### Evaluation assumptions

The evaluation assumptions are provided and discussed in [2][3][4][5][8][10][11][12][13][14][15][16][18]. To facilitate the evaluation and comparison of XR performance, it would be better to align as many assumptions as possible among companies.

According to the input, the evaluation assumptions are listed in Table 1 and Table 2.

Table 1 illustrates the simulation assumptions that are necessary for XR evaluation and for which there is a majority view among companies. So it is recommended to take the simulation assumptions in Table 1 for XR evaluation.

**Table 1: Simulation assumptions for XR evaluation (Part 1)**

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Proposed value** | |
| **Indoor FR1/FR2** | **Outdoor FR1/FR2** |
| Layout | 120m x 50m ISD: 20m TRP numbers: 12 | 21cells with wraparound |
| Carrier frequency | FR1: 3.5 GHz  FR2: 28 GHz | |
| Bandwidth | FR1: 100 MHz  FR2: 400 MHz | |
| Subcarrier spacing | FR1: 30 kHz  FR2: 120 kHz | |
| BS height | 3m | 25m |
| UE height | hUT=1.5 m | |
| UE power | FR1: 23 dBm  FR2: Maximum EIRP 43 dBm | |
| BS noise figure | FR1: 5 dB  FR2: 7 dB | |
| UE noise figure | FR1: 9 dB  FR2: 13 dB | |
| BS receiver | MMSE-IRC | |
| UE receiver | MMSE-IRC | |
| Channel estimation | Realistic | |
| UE speed | 3 km/h | |
| MCS | Up to 256QAM | |
| Target BLER | 10% | |
| Max number of HARQ transmissions | 4 | |
| BS antenna pattern | Ceiling-mount antenna radiation pattern, 5 dBi | 3-sector antenna radiation pattern, 8 dBi |
| UE antenna pattern | FR1: Omni-directional, 0 dBi,  FR2: UE antenna radiation pattern model 1, 5dBi | |

**Proposal 1: Adopt the simulation assumptions in Table 1 for XR evaluation**

**Q8. Please share your comments on the proposal 1.**

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Table 2 illustrates the simulation parameters that are necessary for XR evaluation and are not converged yet. For these assumptions, options proposed by companies are given in the table. To reduce the simulation work, it is recommended for companies to consider to down-select from the options for the assumptions in Table 2. Furthermore, since power control, transmission scheme, PDCCH/DMRS overhead, CSI feedback mechanism and processing delay would affect the capacity performance, these assumptions need to be reported by companies

**Table 2: Simulation assumptions for XR evaluation (Part 2)**

|  |  |  |
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| **Parameter** | **Proposed value** | |
| **Indoor FR1/FR2** | **Outdoor FR1/FR2** |
| UE distribution | 100% indoor | Option 1: 80% indoor, 20% outdoor (HW, vivo, CATT, ZTE, QC-FR1)  Option 2: 20% indoor, 80% outdoor (vivo, Intel)  Option 3: 100% outdoor (MTK, AT&T-FR2, QC-FR2) |
| Frame structure | FR1:  Option1: DDDSU (HW, vivo, E///)  Option2: DSUUD (CATT)  Option3: DDDSUDDSUU (vivo, MTK)  Option4: SUUDD (MTK)  Option5: DDDUU (CMCC)  Option6: DU (CMCC)  Option7: FDD (MTK, IDC, Nokia)  FR2:  Option 1: DDDSU (vivo, MTK)  Option 2: DSUUD (CATT)  Note: S is 10:2:2 | |
| BS antennas | FR1:  32 TxRU, (M, N, P, Mg, Ng; Mp, Np) = (4,4,2,1,1;4,4) (vivo, CATT)  (dH, dV) = (0.5, 0.5)λ  FR2:  64 TxRU, (M, N, P, Mg, Ng; Mp, Np) = (8,8,2,1,1;4,8) (vivo)  2 TxRU, (M, N, P, Mg, Ng; Mp, Np) = (16, 8, 2,1,1;1,1) (QC)  (dH, dV) = (0.5, 0.5)λ | FR1:  Option 1: 64 TxRU, (M, N, P, Mg, Ng; Mp, Np) = (12,8,2,1,1;4,8) (HW, vivo)  Option 2: 64 TxRU, (M, N, P, Mg, Ng; Mp, Np) = (8,4,2,1,1;8,4) (ZTE)  Option 3: 64 TxRU, (M, N, P, Mg, Ng; Mp, Np) = (8,8,2,1,1;4,8) (QC)  Option 4: 64 TxRU, (M, N, P, Mg, Ng; Mp, Np) = (16,8,2,1,1;4,8) (CATT)  Option 5: 32 TxRU, (M, N, P, Mg, Ng; Mp, Np) = (8,8,1,1,2;4,4) (MTK)  Option 6: TxRU, (M, N, P, Mg, Ng; Mp, Np) = (2, 8, 2, 1, 1;2,8) (E///)  (dH, dV) = (0.5λ, 0.8λ)  FR2:  Option 1: 2 TxRU, (M, N, P, Mg, Ng; Mp, Np) = (4,8,2,2,2;1,1) (vivo)  Option 2: 2 TxRU, (M, N, P, Mg, Ng; Mp, Np) = (32,8,2,1,1;1,1) (QC)  (dH, dV) = (0.5λ, 0.5λ) |
| UE antennas | FR1:  2 or 4Tx/2 or 4Rx, (M, N, P, Mg, Ng; Mp, Np) = (1,2,1/2,1,1;1,2)  (dH, dV) = (0.5, N/A)λ  FR2: 4 Tx/4Rx,  Option 1: (M, N, P, Mg, Ng; Mp, Np) = (1,2,2,1,2;1,2) (MTK)  Option 2: (M, N, P, Mg, Ng; Mp, Np) = (2,4,2,1,2;1,2) (vivo)  Option 3: {2, 2, 2} per panel. Number/location of panels: 3 panels (left, right, and top) (QC)  (dH,dV) = (0.5, 0.5)λ  The polarization angles are 0° and 90° | |
| Downtilt | FR1:  Option 1: 6 degree (ZTE, QC)  Option 2: 14 degree (MTK, E///)  Option 3: 100 (Intel)  Option 4: 90° in GCS (pointing to horizontal direction) (vivo)  FR2:  Option 1: 0 degree (MTK)  Option 2: 180° in GCS (pointing to the ground) (vivo) | |
| BS power | FR1:  Alt1: 24dBm/20MHz (vivo, CATT, QC)  Alt2: 30dBm (ZTE)  FR2:  Alt1: Maximum EIRP 58dBm (vivo)  Alt2: 23dBm (QC) | FR1:  Alt1: 46dBm (IDC)  Alt2: 49dBm (E///)  Alt3: 44dBm/20MHz (HW, CATT, ZTE, MTK, Intel, QC)  Alt4: 53dBm (vivo)  FR2:  Alt1: Maximum EIRP 73dBm (vivo)  Alt2: 37dBm (MTK)  Alt3: 28dBm (QC) |
| Power control parameter | Companies should report | |
| Transmission scheme | Companies should report, such as Type I/II codebook, rank assumption | |
| Scheduler | MU-MIMO PF scheduler,  other scheduler is up to companies report | |
| CSI Feedback | Realistic  Companies should report CSI feedback delay, CSI report periodicity, whether using CSI quantization, CSI error model or not, and etc. | |
| PHY processing delay | UE Capability #1 Companies should report gNB processing delay, e.g. DL NACK to retransmission delay, UL previous transmission to current transmission delay and etc. | |
| PDCCH overhead | Companies should report | |
| DMRS overhead | Companies should report | |

**Proposal 2: Regarding the UE distribution for outdoor scenario, down-select from the following options for XR evaluation.**

* **For outdoor scenario:** 
  + **FR1:** 
    - **Option 1: 80% indoor, 20% outdoor**
    - **Option 2: 20% indoor, 80% outdoor**
    - **Option 3: 100% outdoor**
  + **FR2:** 
    - **100% outdoor**

**Q9. Please share your comments on the proposal 2.**

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**Proposal 3: Regarding the frame structure, down-select from the following options of FR1 and FR2 for XR evaluation.**

* **FR1:** 
  + **Option1: DDDSU**
  + **Option2: DSUUD**
  + **Option3: DDDSUDDSUU**
  + **Option4: SUUDD**
  + **Option5: DDDUU**
  + **Option6: DU**
  + **Option7: FDD**
* **FR2:** 
  + **Option 1: DDDSU**
  + **Option 2: DSUUD**

**Note: S is 10:2:2**

**Q10. Please share your comments on the proposal 3.**

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| **Company** | **Comment** |
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**Proposal 4: Regarding the BS antennas, further discuss the assumptions and down-select from the following options for XR evaluation.**

* **For indoor scenario:** 
  + **FR1:** 
    - **32 TxRU, (M, N, P, Mg, Ng; Mp, Np) = (4,4,2,1,1;4,4)**
    - **(dH, dV) = (0.5, 0.5)λ**
  + **FR2:**
    - **64 TxRU, (M, N, P, Mg, Ng; Mp, Np) = (8,8,2,1,1;4,8)**
    - **2 TxRU, (M, N, P, Mg, Ng; Mp, Np) = (16, 8, 2,1,1;1,1)**
    - **(dH, dV) = (0.5, 0.5)λ**
* **For outdoor scenario:** 
  + **FR1:**
    - **Option 1: 64 TxRU, (M, N, P, Mg, Ng; Mp, Np) = (12,8,2,1,1;4,8)**
    - **Option 2: 64 TxRU, (M, N, P, Mg, Ng; Mp, Np) = (8,4,2,1,1;8,4)**
    - **Option 3: 64 TxRU, (M, N, P, Mg, Ng; Mp, Np) = (8,8,2,1,1;4,8)**
    - **Option 4: 64 TxRU, (M, N, P, Mg, Ng; Mp, Np) = (16,8,2,1,1;4,8)**
    - **Option 5: 32 TxRU, (M, N, P, Mg, Ng; Mp, Np) = (8,8,1,1,2;4,4)**
    - **Option 6: TxRU, (M, N, P, Mg, Ng; Mp, Np) = (2, 8, 2, 1, 1;2,8)**

**(dH, dV) = (0.5λ, 0.8λ)**

* + **FR2:**
    - **Option 1: 2 TxRU, (M, N, P, Mg, Ng; Mp, Np) = (4,8,2,2,2;1,1)**
    - **Option 2: 2 TxRU, (M, N, P, Mg, Ng; Mp, Np) = (32,8,2,1,1;1,1)**

**(dH, dV) = (0.5λ, 0.5λ)**

**Q11. Please share your comments on the proposal 4.**

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**Proposal 5: Regarding the UE antennas, adopt the following assumption for FR1 and down-select from the following options for FR2 for XR evaluation.**

* **FR1:** 
  + **2 or 4Tx/2 or 4Rx, (M, N, P, Mg, Ng; Mp, Np) = (1,2,1/2,1,1;1,2)**

**(dH, dV) = (0.5, N/A)λ**

* **FR2: 4 Tx/4Rx,**
  + **Option 1: (M, N, P, Mg, Ng; Mp, Np) = (1,2,2,1,2;1,2)**
  + **Option 2: (M, N, P, Mg, Ng; Mp, Np) = (2,4,2,1,2;1,2)**
  + **Option 3: {2, 2, 2} per panel. Number/location of panels: 3 panels (left, right, and top)**

**(dH,dV) = (0.5, 0.5)λ**

**The polarization angles are 0° and 90°**

**Q12. Please share your comments on the proposal 5.**

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**Proposal 6: Regarding the downtilt, down-select from the following options for FR1 and FR2 for XR evaluation.**

* **FR1:** 
  + **Option 1: 6 degree**
  + **Option 2: 14 degree**
  + **Option 3: 100**
  + **Option 4: 90° in GCS (pointing to horizontal direction)**
* **FR2:** 
  + **Option 1: 0 degree**
  + **Option 2: 180° in GCS (pointing to the ground)**

**Q13. Please share your comments on the proposal 6.**

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**Proposal 7: Regarding the BS Tx power, down-select from the following options for XR evaluation.**

* **For indoor scenario:** 
  + **FR1:** 
    - **Alt1: 24dBm/20MHz**
    - **Alt2: 30dBm**
  + **FR2:** 
    - **Alt1: Maximum EIRP 58dBm**
    - **Alt2: 23dBm**
* **For outdoor scenario:** 
  + **FR1:** 
    - **Alt1: 46dBm**
    - **Alt2: 49dBm**
    - **Alt3: 44dBm/20MHz**
    - **Alt4: 53dBm**
  + **FR2:**
    - **Alt1: Maximum EIRP 73dBm**
    - **Alt2: 37dBm**
    - **Alt3: 28dBm**

**Q14. Please share your comments on the proposal 7.**

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**For the following assumptions in Table 2, they are important for the XR evaluation and may be related to the implementation/configuration. Hence, they should be reported by company with detailed assumptions for the evaluation.**

**Proposal 8: Adopt the following simulation assumptions in Table 2 for XR evaluation.**

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| **Power control parameter** | Companies should report |
| **Transmission scheme** | Companies should report, such as Type I/II codebook, rank assumption |
| **Scheduler** | MU-MIMO PF scheduler,  other scheduler (e.g., delay aware scheduler) is up to companies report |
| **CSI Feedback** | Realistic  Companies should report CSI feedback delay, CSI report periodicity, whether using CSI quantization, CSI error model or not, and etc. |
| **PHY processing delay** | UE Capability #1 Companies should report gNB processing delay, e.g. DL NACK to retransmission delay, UL previous transmission to current transmission delay and etc. |
| **PDCCH overhead** | Companies should report |
| **DMRS overhead** | Companies should report |
| **SRS** | Companies should report |

**Q15. Please share your comments on the proposal 8.**

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**Q16. Please share additional comments if any on Table 2.**

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**Q17: In addition to the assumptions in Table 1 and Table 2, are there any assumptions which are necessary to define for XR evaluation?**

**Please share your comments on the Q17.**

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The following simulation assumptions are proposed by one or only a few companies for XR evaluation. More clarifications on whether and how to consider these simulation assumptions for the XR evaluation are needed.

* Beam related operation, such as beam update mechanism, beam activation delay, beam metric
* Others, e.g. RLC, network layer setting, core network delay

*FL’s comment: For the assumptions that may be related to traffic model, they can be discussed with traffic model after there is more input from SA4.*

**Q18: Whether or not to consider the following simulation assumptions for XR evaluation?**

* **Beam related operation, such as beam update mechanism, beam activation delay, beam metric**
* **Others, e.g. RLC, network layer setting, core network delay**

**Please share your comments on the Q18.**

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**Q19. Please share any other comments if any on capacity evaluation for XR and CG.**

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| **Company** | **Comment** |
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# Summary

# Reference

1. R1-2007555 XR applications and scenarios FUTUREWEI
2. R1-2007561 Discussion on applications, traffic model, and evaluation methodology for XR and Cloud Gaming Huawei, HiSilicon
3. R1-2007698 Discussion on XR applications, traffic model and evaluation methodologies vivo
4. R1-2007843 XR use cases, evaluation methodologies and traffic model CATT
5. R1-2007976 Discussion on applications, traffic model and evaluation methodology for XR ZTE
6. R1-2008037 Discussion on XR evaluation and Challenges for NR CMCC
7. R1-2008198 Applications, Evaluation Methodology, and KPIs for XR Samsung
8. R1-2008311 XR evaluations for NR: Applications and Evaluation Methodology AT&T
9. R1-2008454 XR Applications, Traffic Model and Evaluation Methodology Apple
10. R1-2008818 Discussion on traffic models and evaluation assumptions for XR InterDigital, Inc.
11. R1-2008896 Applications, Traffic Model and Evaluation Methodology for XR evaluations for NR Nokia, Nokia Shanghai Bell
12. R1-2008939 Discussion for study in XR evaluation for NR LG Electronics
13. R1-2008967 On Applications, Traffic Model, and Evaluation Methodology for XR and CG MediaTek Inc.
14. R1-2009006 Scenarios, Traffic Model and EVM for XR Intel Corporation
15. R1-2009041 Discussion on XR application and evaluation methodology Xiaomi
16. R1-2009087 XR use cases, traffic modelling and performance measure Ericsson
17. R1-2009198 Discussion on study on XR evaluations for NR NTT DOCOMO, INC.
18. R1-2009280 Evaluation Methodology for XR Qualcomm Incorporated

# List of agreements