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| SparkLink mmWave | |
| Use Case Description Format & Version Management Proposal  Front page to be used from ver 0.0.0 till ver 1.0.0 | |
| Title / Number | XR (Extended Reality) for Industrial, eHealth and entertainment applications / UC1\_XR |
| UC introduced in meeting no. | 15th January 2025; Meeting no.2 Malaga, Spain |
| Presenting Member/ individual Ver 0.0.0 | Vinod Kumar, WWRF representative |
| Sponsoring Members (Optional) | Huawei, Lenovo, Chipset Vendors, XR Vision Equipment Vendors |
| Intended Market Segments | Consumer, Medical, Automotive, IT Infrastructure, Industrial, Military |
| Ecosystems | Chipset, modules, device manufacturers  network operators involved (to be clarified) |

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| Place Holder for managing the Use Case evolution in the TG Meetings | | | |
| TG Meeting No | Input version Ver 0.a.b | Output Version  Ver 0.c.d | Updates Introduced |
|  | Ver 0.0.0 | Ver 0.1.2 | “Deployment Scenarios” Paragraph |
|  | Ver 0.1.2 | Ver 0.2.3 | Further details on   * XR parameters, bit rate, Latency, FoV * LBT Categories suitable for XR |
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| Objective | Design of wireless transmission mechanisms for satisfying bit rate and latency requirements of different applications of XR concepts. |
| Description | XR englobes AR (Augmented Reality), MR (Mixed Reality) and VR (Virtual Reality). Existing, usually tethered, XR devices offer a limited user mobility and reduced QoE (Quality of Experience). Implementation of (sometimes asymmetrical) bi-directional transmission, at speeds ranging from a few kb/sec to several Gb/sec (even a few Terabits/sec) is required for the operation of XR devices.  Wireless XR is realizable in the high GHz mmWave spectrum (e. g 60 GHz). Depending on the application domain, XR radio transmission would be deployed the in the licensed or unlicensed band. 4G, 5G (NR), WiFi 6 standards for mid-rate (upto <100 Mb/sec) transmission already exist and WiGig and 6G have the objective of standardizing the transmission technologies for multi-gigabit XR implementations. |
| Technical Specs related. | XR is a generic term used to designate separately or a combination of AR (Augmented Reality), MR (Mixed Reality) and VR (Virtual Reality). AR/MR images/videos are realized by super-imposing virtual objects on top of real images/videos. AR displays passive virtual contents only whereas MR allows users to interact with active virtual objects. VR does not require videos of the real environment since all the presented contents are virtual. Applications based on immersive and non-immersive XR experience exist. AR and MR are mainly used for assistance, training, tourism (guides) whereas VR is essential for gaming and immersive video (movies) experience. Smart phones, tablets and other handheld devices with cameras are suitable for non-immersive AR/MR experience whereas an immersive VR experience requires an Optical Head mounted device.  (N.B In AV (Augmented Virtuality) surrounding Virtual Environment is enriched with real objects).  **A typical XR set-up consists** of one or multiple XR devices (e.g Head mounted glasses with translucent screen (for AR and MR), Occulent glasses (for VR), tablets, portable PC) interacting with a central or an edge server through an air interface. The end application and the required resolution of the XR device and the connectivity scenario determine the UL (Device to Server) and the DL (Server to Device) transmission rates. For AR/MR applications the UL/DL transmission rates are quite symmetrical. The VR implementation usually requires very widely different UL (rather low) and DL (much higher) transmissions rates.  **Characteristic parameters of XR** devices are some of the other factors affecting the UL/DL Data rates. Such parameters include FoV (field of View), PPD (Pixels per degree), resolution and (frame) referesh rate. For a given resolution large FoV results in a small PPD and VR displays providing large FoV for immersive experience use a small PPD. The Refresh Rate (the number of frames displayed per second) determines the level of comfort (or discomfort) for an XR experience. Minimum refresh rate of 90 is a basic XR requirement.  Further, it can be noted, as an example, that 8K resolution VR demands 1.2 Gb/sec transmission rate to satisfy the 20ms photon to motion latency requirement.  More numerical details related to these parameters may be provided in an annexe.  **Information (rendering) latency is** another parameter to be considered for good QoE in XR. More specifically, it is the time required to display a new frame (say frame B) which was generated after some modification provoked by e. g new sensor information in the presently being displayed frame A.  The latency tolerance requirements for MR are more strict than for AR due to the fact that MR needs to interact with “dynamic” virtual objects. The latency tolerance in VR application dependent. For highly interactive gaming the latency tolerance is quite low and ultra-low latency is required whereas for VR applications (movies, immersive videos involving low user interaction quite high latency tolerance is acceptable.  **Some of the typical values** in (present day) XR are  **AR** – UL-Data Rate: 0.02 to 1Gb/sec; DL-Data Rate: 0.02 to 1Gb/sec; Latency – 20ms; Refresh Rate: 90; PPD: 30 to 60; FoV 20° - 50°;  **MR** – All same as above except Latency: 10ms  **VR -** UL-Data Rate: 150 kb/sec; DL-Data Rate: 0.02 to 1Gb/sec; Latency – 20 - 1000 ms; Refresh Rate: 90; PPD: 10 to 15; FoV 100° - 150°  These values related to Stage 1 implementation of XR where wireless is replacing tethered connections. The ultimate (Stage 3) XR will be based on air-interface capable to ensure several Terabit/sec data and 1ms latency.  **Energy Efficiency and Physical Constraints of XR equipmen**t  The QoE is limited by power consumption and weight of the head-mounted XR devices. High power consumption of wireless communication and computation not only drains the battery fast but also generates heating which affects the user experience.  **Connectivity scenarios in XR applications**   1. **One to One**   Simplest case where an XR device connects to an edge server for each session   1. **One to Many**   The case where a single server is talking simultaneously multiple XR nodes with UL in Multiple Access and DL in Broadcast (same information content for all XR nodes) or DL in multi-cast mode.   1. **One to clustered many (Head and Followers)**   The case where one XR node acting as a cluster head would be communicating with an XR server in one to one in DL and relaying DL information to other cluster nodes (followers). Typically the case where a group of visitor on together on a museum visit.   1. **One to multiple clustered many (Heads and Followers)**   Could be a combination of 2 and 3.  Other connectivity scenarios from XR applications in eHealth, Automotive and Industrial control should be appended to this list of scenarios mainly applicable in “Entertainment” related applications. |
| Technical Feasibility / Complexity – Critical path and any Roadblocks | If this can be demonstrated to be feasible and if there are some methods already available – Hopefully only a few bullet points |
| Dependencies | Most of the “Entertainment” related XR applications would be implemented in the un-licensed band. Bandwidth availability in the high GHz range is listed below. The values listed below are Frequency Range, centre frequency and available bandwidth.    Despite the availability of rather large BWs, the release of such spectrum is under strict governmental control. The 9 GHz and 14 GHz spectrum recently released in the 60 GHz range, in Europe and in the USA, respectively, would provide 10× and 16× times more unlicensed spectrum as compared to sub-7 GHz bands in the respective countries. Its benefit in the implementation of high end XR applications would thus be available within these geographically limited markets.  The implementations in unlicensed bands are prone to several types of interference namely   * Geographically collocated networks for different usages operating in the same band for the existing technologies. Example IEEE 802.11ad (WiGig) affecting.. * Geographically collocated networks for different usages operating in the same band from the upcoming technologies. A recent example is the approval of 3GPP Study Item to extend the NR operation up to 71 GHz that means including in the 60 GHz licensed band. * Mutual interference between the nodes belonging to the same network * Interference due to the situations of Primary User against or along with the Secondary User. The case of a SU trying to operate in same geography as a security/defence related PU would be quite critical.   However, interference combating mechanisms to ensure the specified QoE which is a function of frame resolution, frame continuity and rebuffering time, need to be carefully selected. Adaptive Bit Rate (ABR) transmission, one of the simple methods, can introduce additional latency jitter.  The most commonly deployed interference avoidance mechanisms – suitable (?) for XR - are   * CSMA/CA * LBT – Listen before talk * Duty Cycle based operation not requiring the Clear Channel Assessment (CCA)   Regulatory requirements on LBT, maximum Channel Occupancy Time (COT), Occupied Channel Bandwidth (OCB) and power limits need due consideration.  Several variants of LBT have been deployed. The LBT can be based on “server-initiated COT” or “XR initiated COT”. Four Categories of LBT derived from WiFi CSMA/CA and LTE-LAA, are   * Cat1- LBT: immediate transmission (i.e., no LBT). * Cat2 - LBT: LBT without random back-off. * Cat3 - LBT: LBT with random back-off and fixed contention window. * Cat4 - LBT: LBT with random back-off and exponential contention window.   As a general rule, the latency performance with degrade as we go from Cat 2 to Cat 4.  LBT and MAC interaction is another factor to be considered. Starting LBT before the data has been scheduled for transmission may generate in-efficiency in spectrum usage and starting LBT before the data had been scheduled may result in data loss due to a phenomenon called “side clipping”.  Additionally, information latency performance is known to be adversely affected by LBT and CSMA/CA.  Example Deployment Scenarios:  a) Indoors – Residential or office   * Server to XT node Distance: 1m to 10m * Interference types: Multiple access interference, WiFi and Indoors 5G private networks.   b) Indoors – Industrial workshops and transport sites   * Server to XT node Distance: 5m to 50m * Interference types: Multiple access interference, WiFi and Indoors 5G private networks for access and industrial control and CV related deployments.   c) Outdoors – Dense urban business areas and suburban industrial zones   * Server to XT node Distance: 20m to 100m * Interference types: Multiple access interference, WiFi and Indoors 5G private networks and other incumbent users for the mmWave Spectrum   d) Outdoor deployments for Server to XT node distance of > 100m distance appear to be out of scope this use case at the first glance. |
| Innovation | Is there any other SDO working on it? Performance advantage of the proposed solution wrt the existing or upcoming solution from other SDO’s |
| Justification and benefits | Why market needs this, what will be the benefits for that market and what problems the use case will solve. |
| Priority | Defined by the SparkLink Alliance |