Bell Labs Consulting

AR/VR and 5G QoMEX

paper overview

Video Quality Experts Group (VQEG) presentation December 2020
Key concerns/questions telecom operators are asking

- Operators looking to monetize their assets – to create value for their 5G (or LTE network)
- What is required to make VR/AR work on LTE and 5G/Edge Cloud?
- Value creation comes from creating a great user experience (high QoE)
  - How to measure QoE for AR/VR/XR?
  - How to engineer their network to ensure a good user experience?

Network operators need to create a demand for 5G by showcasing its abilities
Cloud delivered AR/VR - market and technology readiness

- AR/VR are computationally complex (CPU limited)
- XR operates locally (HMD)

Why move XR to Cloud?
- Battery life and Heat reduce
- Scalability of app (e.g. obj recog)
- Device ergonomics and portability, app portability and feature adds

GPU have brought possibility of remote AR/VR
- Cloud gaming has similar performance requirements of AR/VR/XR (complex, real time, etc)

Market evolutions towards 5G, Edge Cloud and GPU have enabled AR/VR cloud
How to define QoE for AR/VR

• Each AR/VR application is characterized by features tied to enablers (KQIs)
  - Responsiveness - appl lag
  - Immersion is related to content resolution
  - Image quality – PLR, etc

• Relating KQIs to network KPIs (1080p to throughput)

• Leveraging internal and external research and existing ITU-T standards when possible

• Impairment models were used to characterize degradation

• Combining impairment models using multiplicative model

\[ Q_{XR} = \alpha \times \hat{i}_x \times \hat{i}_y \times \hat{i}_z + \beta \]

Leveraging best practices and existing research to create a method for measuring AR/VR QoE
Engineering the network to meet a desired QoE level

- Correlating NW KPIs to XR KQIs is achieved through customer data analysis (analytics)
- NW operators track KPIs which can be engineered through capacity planning
- Network KPIs like RAN DL throughput can be measured against application throughput
- Network RTT also impacts application throughput
- LTE network load (PRB) or volume (GB/hour) impacts user throughput
- Using traffic growth we can predict future throughput

<table>
<thead>
<tr>
<th>XR KQIs</th>
<th>NW KPIs</th>
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<tbody>
<tr>
<td>Immersion</td>
<td>Latency</td>
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<tr>
<td>Responsiveness</td>
<td>BW (up/down)</td>
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<td>Image quality</td>
<td>Resolution</td>
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<td>FPS</td>
<td>Packet Loss</td>
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Engineering for QoE can be achieved by correlating application KQI targets to KPI performance
Evaluating LTE and 5G QoE based on developed models

Capacity increase is not sufficient for 4K VR Gaming
• Assumption: Cloud latency 190ms, 4G 70ms

Cloud performance GPU and far edge based
• Assumption: Edge Cloud latency 70ms

VR Gaming QoE is enabled by the reduced latency in the edge cloud and 5G network

\[ Q_{VRG} = \alpha \times \hat{I}_{\text{cod}} \times \hat{I}_{\text{lat}} \times \hat{I}_{\text{plr}} + \beta \]