



DISTRIBUTING AR & VR COMPUTE IN A 5G WORLD

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DISTRIBUTING AR & VR COMPUTE IN A 5G WORLD

- Expectations are high that 5G will deliver interactive, immersive experiences
- Engaging immersive content will be required to drive adoption
- 5G brings many technical benefits to AR/VR experiences
- Many barriers to AR/VR adoption can be addressed by 5G
- AR/VR usages put unique requirements on 5G networks
- Different approaches to delivering immersive experiences are being pursued, taking advantage of new HMDs, clients, edge & cloud



5G SMART MEDIA: CONSUMERS WANT MULTI-SENSORY EXPERIENCES

AUGMENTED INSTRUCTION

60% interested in real-time insight from smart equipment with information overlays

ENHANCED SENSORY IMMERSION

57% interested in touch-enabled internet and gaming delivered via haptic suits

PASSENGER ENTERTAINMENT

57% interested in high-definition TV or video conferencing during travel in self-driving cars

ULTIMATE MOVIE CONTROL

60% interested in choose-your-own-adventure functionality for storylines and camera angles

3D HOLOGRAPHIC SHOWS

59% interested in multi-angle 3D-character images that don't require assistive gear

LIVING THE ACTION AT LIVE EVENTS

57% interested in app-driven sports and concerts that deliver up-close vantage points

3D VIDEO THAT COMES TO LIFE

64% interested in AR-enabled virtual objects and characters that move about the real world

FULLY IMMERSIVE SURROUND VIDEO

60% interested in a lifelike 360-degree documentary or movie using a VR headset

ONE SEAMLESS 5G HOME

71% interested in 5G for all connected-home needs, including bundled internet and TV

TOP AR/VR USAGES*

	VR	AR
Consumer	<ul style="list-style-type: none"> • Games • Immersive Video • Education & Training 	<ul style="list-style-type: none"> • Games • Education & Training
Commercial	<ul style="list-style-type: none"> • Film Production & Amusement • Virtual Property Tours • Product Development 	<ul style="list-style-type: none"> • Retail Showcasing • Industrial Maintenance • Onsite Assembly & Safety



*IDC Worldwide Semiannual Augmented and Virtual Reality Spending Guide, Dec 2018

INTEL AT THE FOREFRONT OF CREATING VR CONTENT

Intel® TrueVR: Live streaming VR content

- Broadcasted March Madness 2019
- Agreements with MLB, NCAA, NFL
- Announced multi-year engagement with Olympics

Intel® True View: watch the biggest moments in sports from every angle

- Intel Studios here in LA is the world's largest stage for volumetric video capture



WIRELESS VR ENABLED BY INTEL WIGIG



Now Available

System Requirements:

- Desktops: PCIe add-in card + external antenna (available now)

*"[WiGig] seems to provide exactly what VR fans have wanted for years: a **high-performance**, reliable wireless VR solution."*

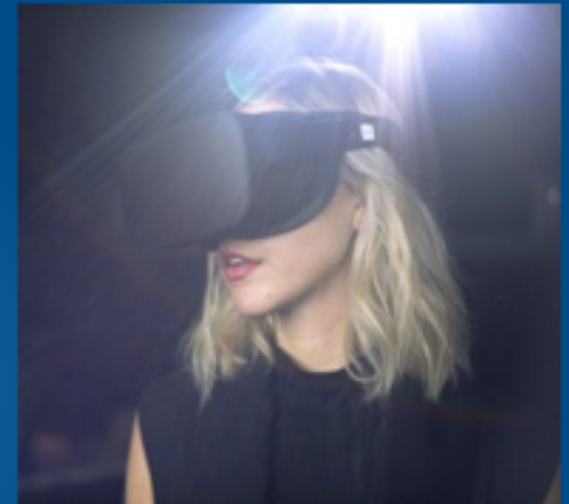
– GameCrate

*"The sheer sense of liberating freedom achieved from **cutting the cord**... cannot be overstated."*

– Upload

WHAT DOES 5G BRING TO AR/VR?

- Order of magnitude increase in data rates, up to 10Gbits/s
 - 60x **Faster than current cable** internet (~150Mbps)
 - 100x faster than 4G LTE
- Increase in bandwidth in both directions
- Lower network latency – below 1ms compared with 30-70ms for 4G
 - End-to-end AR/VR solutions likely to be ~10-20ms, just within typical VR motion-to-photon target of <20ms
- Support for greater density of connections
- Providers use the Edge to bring compute closer to the home/business
- All delivered **wirelessly**



5G BENEFITS FOR AR/VR USERS

User Benefits:

- Wireless experiences throughout the home/business
- AR experiences delivered while mobile and outdoors (in urban environments)
- Thinner clients due to distributed compute (Client, Edge, Cloud)
- Central services in the cloud & edge
 - Distributed security – better? Or easier to hack?
- Better streaming and sharing with lower latency
- More opportunities for streaming real-time content (e.g. sports)
- Share compute with/from your neighbor?



5G AND CLOUD REDUCE USER BARRIERS TO AR/VR ADOPTION

Opportunity	Solution
Reduce "Time to fun". It takes too long to download and update.	5G increases bandwidth for download
I want to play VR with my existing device, don't want to have to upgrade my PC/HMD	Cloud and Edge compute reduces requirements on client
I want to play where and when on device I want	5G enables high bandwidth wireless connection, allows free-range use within the home and mobile AR use when outdoors
I want to have a social/competitive experience, share my experience without impacting my game	Keep more compute in the cloud and in the edge, better quality streaming
My AR/VR Headset/glasses are too bulky and heavy on my head	Shifting compute to the cloud/edge means HMD/glasses can be lighter but need to make trade-offs between battery life and comfort
I want my AR/VR experience to be secure. I want my privacy	Could be harder to hack/cheat, but if hack is successful, impact would be greater

VR OVER 5G SOLUTIONS ARE IN PROGRESS

Intel , Sony Pictures Virtual Reality & Nokia

demo "Spider-man Far From Home, the world's first multi-player virtual reality environment over 5G" at MWC.

ATT & HTC

Show PoC delivering 2880x1600 @75Hz VR with 5ms latency.

SK Telecom

Offers Okusu VR experiences with no data limits

- Social VR experience
- Immersive videos
- Niantic's *Harry Potter: Wizards Unite*



SK Telecom offers early 5G users free VR, 4K videos, and mobile games



The game was an example of 5G's potential power.

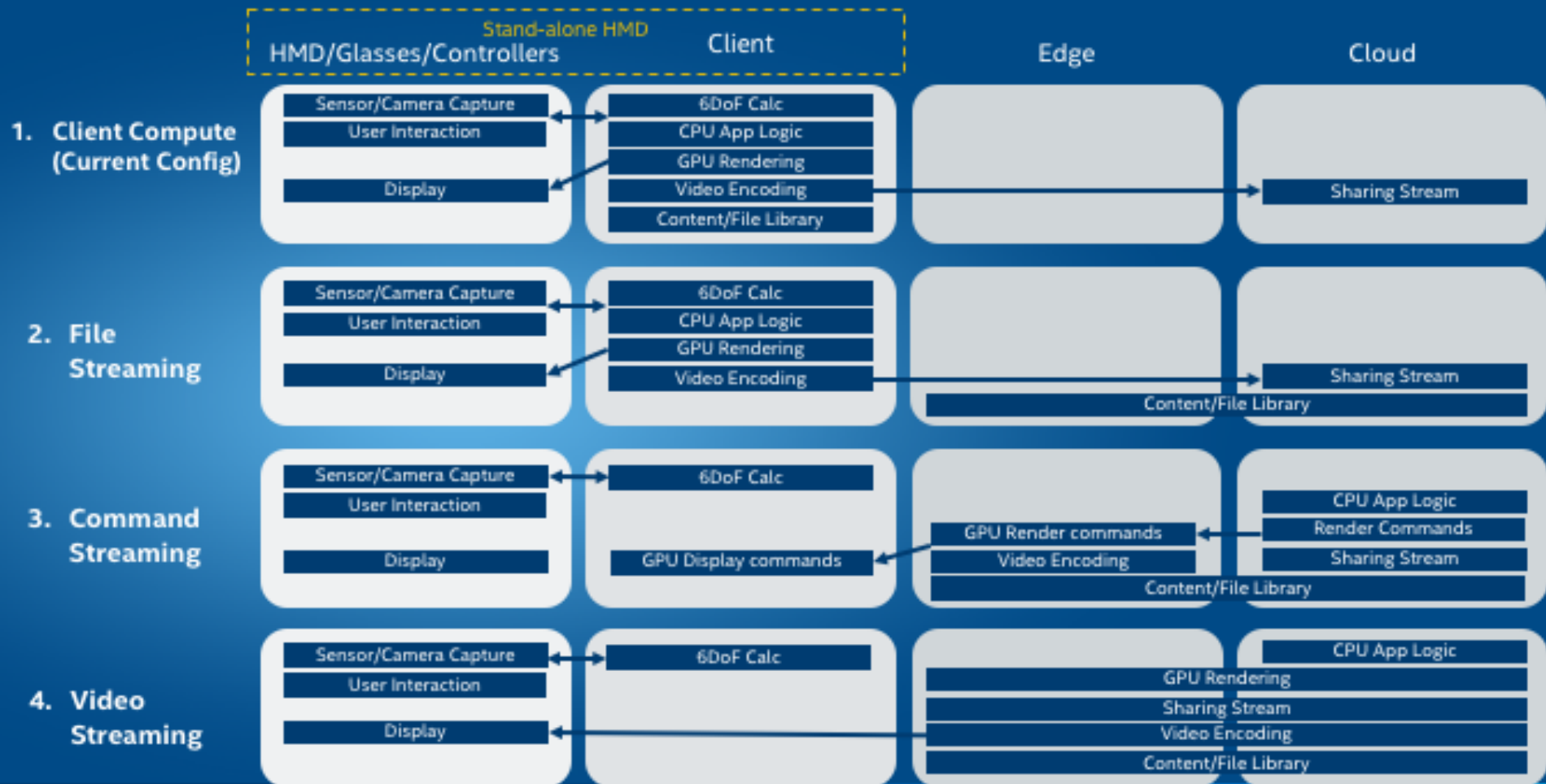


AR/VR REQUIREMENTS FOR 5G NETWORKS

- **High Resolution Stereo Displays**
 - Support transmission of stereo video at resolutions of 1440x1600 per eye @90fps and moving towards 4K per eye by 2023
- **3DoF, 3DoF+, 6DoF Video Streaming**
 - Support back-channel transmission of stereo cameras and IMU data for 6DoF calculations and video pass-through
 - Encoding at the edge and/or cloud for viewpoint
- End-to-end latency of 10-20ms with a 90fps refresh rate
- Fast file app download rates.
- Storage of files in the cloud, edge and client
- All day battery life for client/HMD/Glasses



POSSIBLE DISTRIBUTED COMPUTE CONFIGURATIONS



NEXT STEPS TO DELIVER THE 5G IMMERSIVE EXPERIENCES

Hardware:

- Develop lighter, wireless, and safe AR/VR display devices

Software:

- Design for 2-way interactivity
- Design for distributed compute
- Open SDKs for greatest HW compatibility

Network

- Edge introduces opportunity to reduce latencies at the last mile

Solutions:

- Build open, end-to-end solutions that optimize at all data points.



+others

