uCPE Edge Computing for Real-Time Rendering and Interactions in the Metaverse

Lichuan Ren[1], Jinyi Huang[1], Jamie Wang[1], Grace Zhu[1], Daniel Wang[1], Jordan Lambert[2], Yanyan Zheng[2], Zheng Li[2], Sandra Liu[2], Vivian Ye[2], Alan Yen[2], Larry Zhou[2], David Mahar[2], John Gibbons[2], and Michael Satterlee[2]

[1]AT&T Labs Internship Program, [2]AT&T Labs

Introduction

Key Challenges of Metaverse:

- Digitization of the virtual world is not automatic
- Avatar is not hyper-realistic
- Controller based interaction is not human-natural
- Limited processing power in HMDs causes jittering and stuttering
- Complexity in rendering and network transportation limits use cases

To provide an immersive and hyper-realistic metaverse, it requires:

- high bandwidth network with low latency and low jitter
- powerful edge computing 3D rendering close to the users
- Users' ability to create realistic 3D human model and Digital Twins
- large storage for Metaverse materials and assets

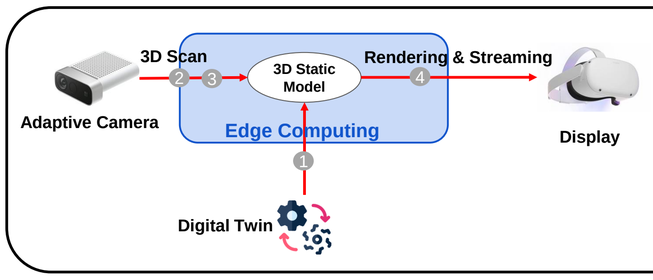
Our Approach – Edge Computing integrated with AT&T uCPE:

- Meets users' needs for various CPU, GPU, port density and features with multiple models
- Deploys at various locations, customer home, enterprise building and 5G Mid-Haul
- Provides large storage with low latency, and high bandwidth networking

Our Design:

- Enhances AT&T uCPE with built-in GPU, hardware accelerator and high-speed ports
- Provides best path selection with AT&T 5G Network Slicing and Segment Routing for low latency/jitter

Design

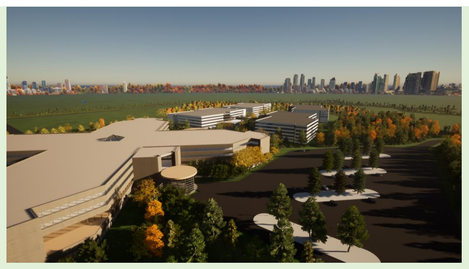


Data flow:

1. Create a virtual world as 3D Static Model
2. Create real-time Dynamic Model from real human
3. Apply Hand Gesture Recognition in virtual world interaction
4. Use Edge Computing for real-time rendering & data streaming

1. Static Model

- Create 3D building models using Rhino and Blender
- Use Unreal Twinmotion to render and contextualize the built environment



AT&T Labs

Bell Works

2. Dynamic Model

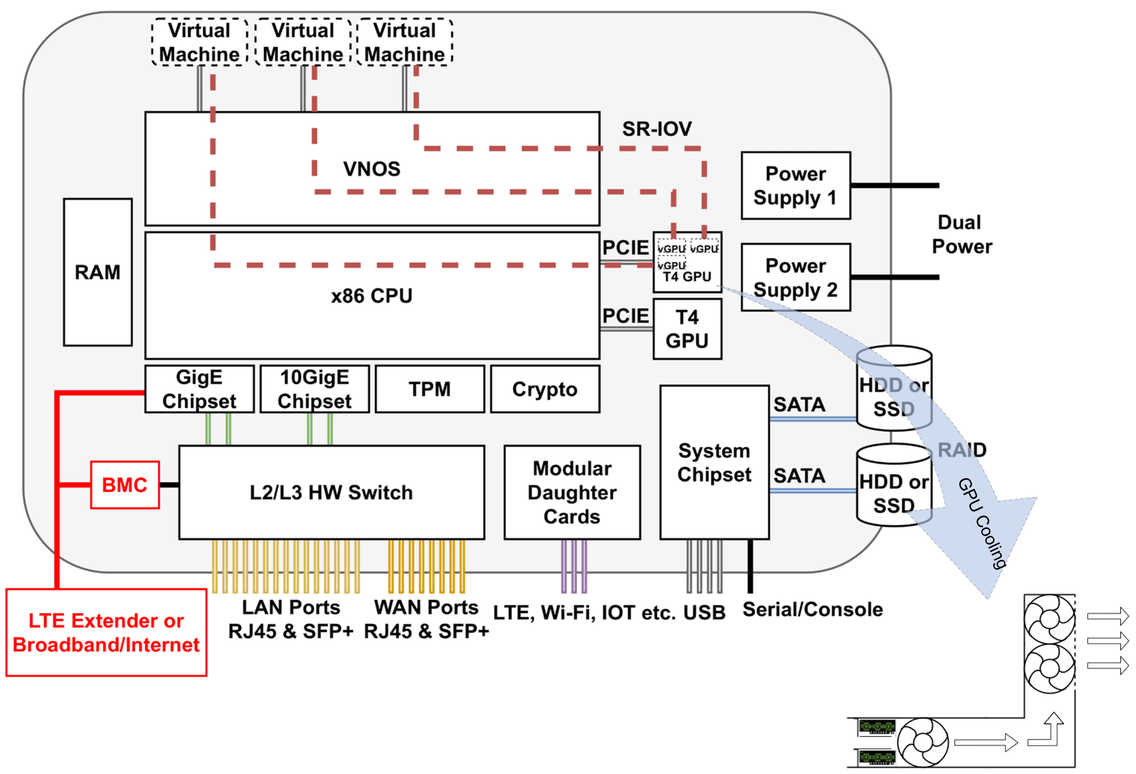
- Build dynamic real human 3D model using 3D data acquisition, real-time photogrammetry, multi-view RGB-D images, camera calibration, and pose estimation
- Apply Hand Gesture Recognition using NN-methods and heuristic-methods for human-natural interaction in the Metaverse

3. Real-Time Rendering on Edge Computing with enhanced AT&T uCPE

- Merge Static Model and Dynamic Model to create real-time 3D model in the interactive Metaverse

Implementation

Hardware Design of uCPE with Edge Computing Enhancement



Why uCPE?

- Plug-and-play capabilities
- Cloud-native management and control
- Built-in 10G switch
- Flexible add-on
- 3rd party modules
- Ease of use

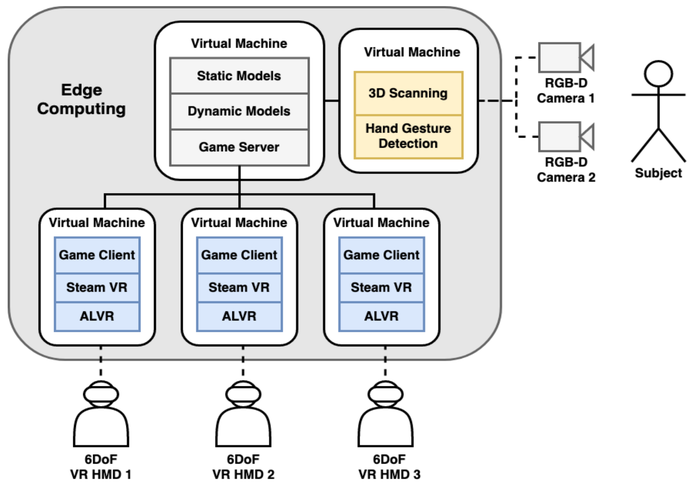
Enhancements:

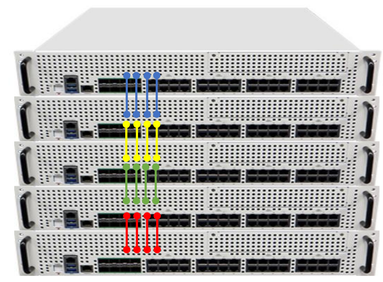
- NVIDIA Tesla T4 GPUs: support GPU virtualization
- SR-IOV PCIe: Provides virtual machines with virtual GPUs (vGPUs) for 3D rendering
- Network Function and Edge Computing full integration

Cooling:

- Enhanced with additional cooling system for Tesla-T4 GPU (Passive Cooling)
- Tested below 60 °C at peak performance

uCPE Edge Computing Enhancement and Scale





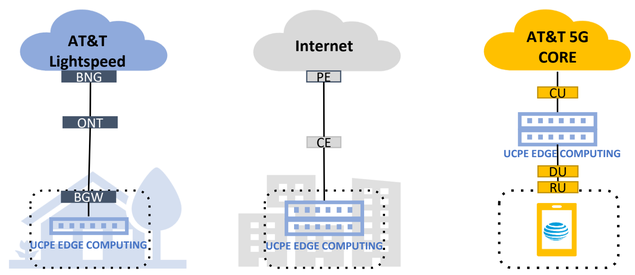
Edge Computing VM:

- One VM per HMD (user) with its own vGPU and VR streaming stack
- Interactive contents rendered first in VM before streamed to its HMD

Solution scales to 80 Users (Tesla-T4GPU, 8x10G BE uCPE backplane):

- 2 GPUs/uCPE
- 16G RAM/GPU
- 4G RAM/vGPU
- 8 Users/uCPE
- Up to 10 uCPE stacking

Edge Compute Deployment Location



uCPE Edge Compute Use Cases:

- Deployed at private 5G between DU and CU
- Deployed at Enterprise Company's Branch or Headquarter location
- Deployed at Residential Home or SMB

Summary

What we learned:

- It is extremely difficult to build a hyper-realistic Metaverse for hundreds of users with ultra immersive experiences. Battery powered standalone HMDs can not cut it with its smartphone-like compute power
- AT&T uCPE Edge Computing delivers ample computational power, sufficient data storage, tightened security to provide interactive metaverse experience
- In addition, AT&T uCPE edge computing provides the rendering power to create Digital Twins in the Metaverse
- Flexible deployment of AT&T uCPE edge computing(right next to the users) opens the opportunities for light-weight low-cost HMDs

Get in touch with us:

Larry Zhou: lz4257@att.com