Towards a Workload Trace Archive for Metaverse Applications

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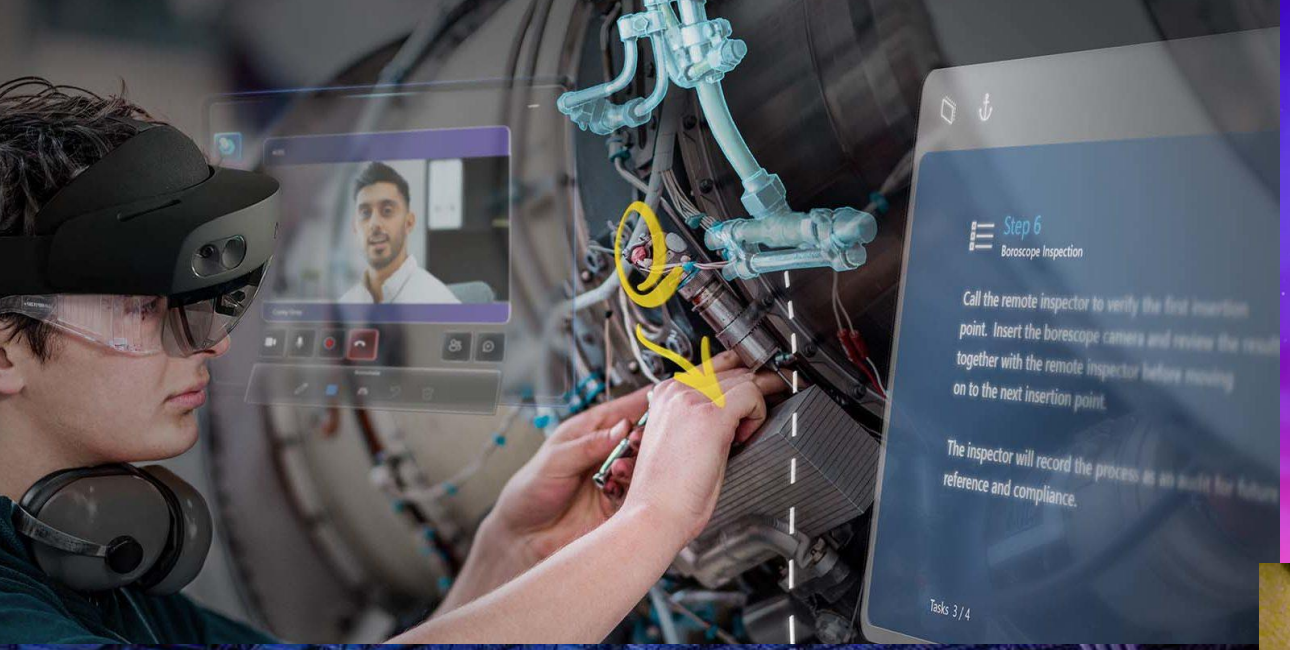

@Large Research
Massivizing Computer Systems

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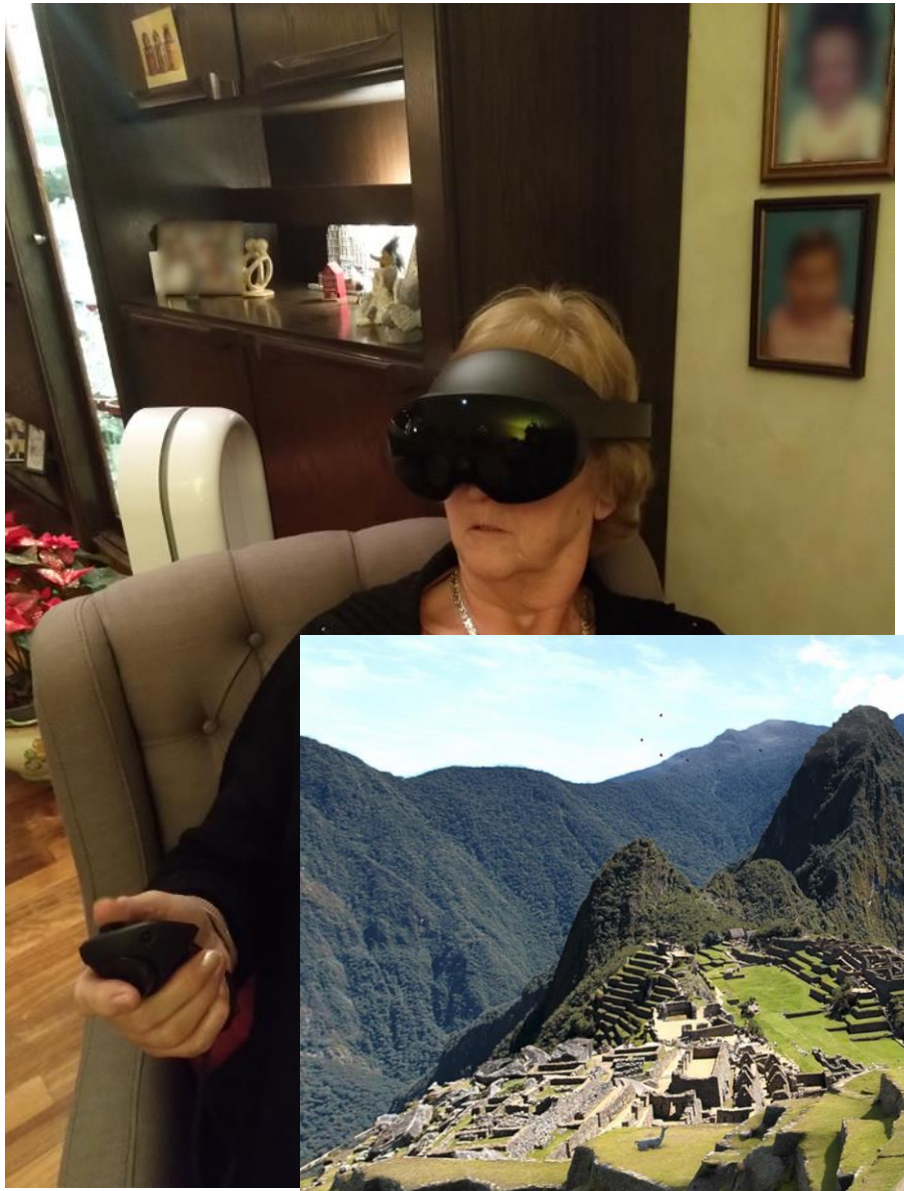


NATIONAL
GEOGRAPHIC
EXPLORE VR

PHENOMENON: PERFORMANCE DROPS IN VIRTUAL WORLDS

SECOND LIFE

ROBLOX

MINECRAFT

Polygon

Source: http://bit.ly/EveOnline21Crash

NEWS

Players in Eve Online broke a world record — and then the game itself

Developers said they're not 'able to predict the server performance in these kinds of situations'

By Charlie Hall | @Charlie_L_Hall | Jan 5, 2021, 2:54pm EST

Source: Razorien/CCP Games

How to Deploy Metaverse Infrastructure?

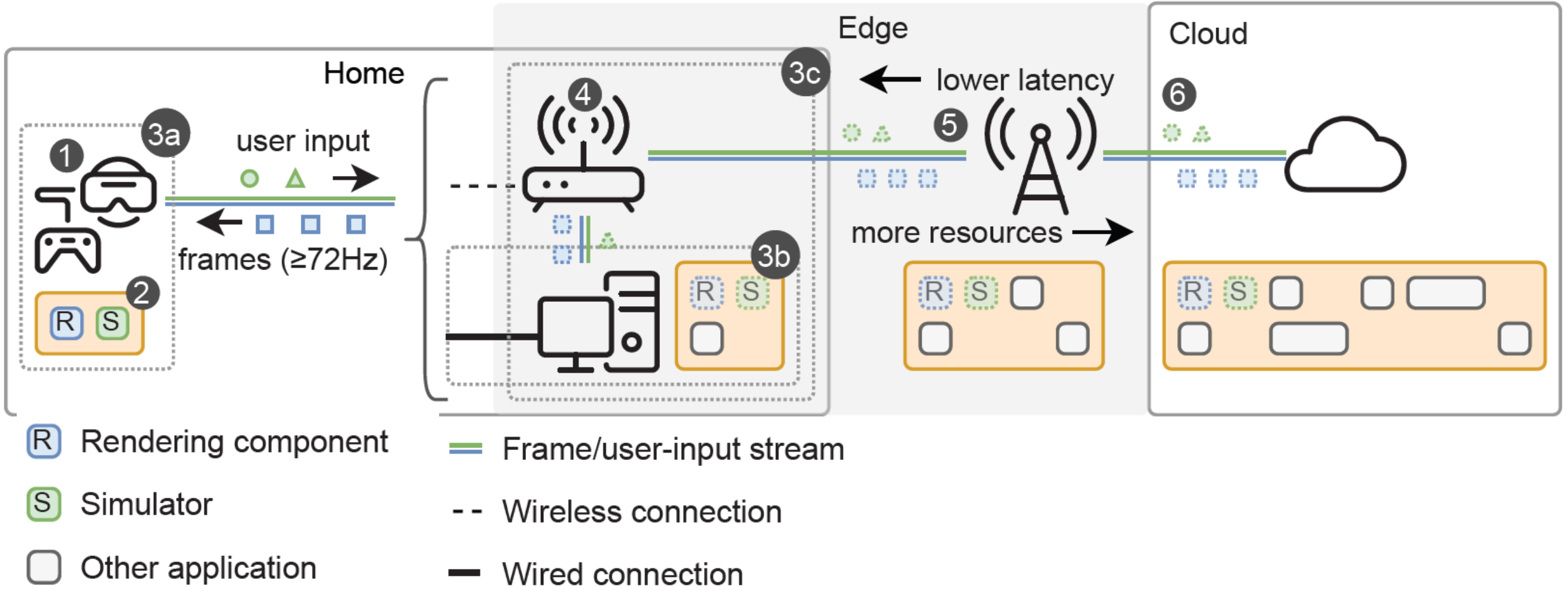


Figure source: *Can My WiFi Handle the Metaverse? A Performance Evaluation Of Meta's Flagship Virtual Reality Hardware*, Jesse Donkervliet, Matthijs Jansen, Animesh Trivedi, Alexandru Iosup (2023), ICPE HotCloudPerf 2023

How to Deploy Metaverse Infrastructure?

How to answer this question?

This talk

1. Performing real-world experiments with VR devices is labor intensive, devices are scarce and expensive
2. No publicly available datasets to explore
3. No simulators for the metaverse

Our Approach

1. We design a tracing system to simplify and partially automate performing real-world experiments with VR devices
2. Through real-world experiments, we create an initial **dataset for metaverse systems**
3. Future work: use datasets to create a simulator to explore metaverse system behavior for a fraction of the cost (time, money)

User Input Tracing with Record-n-Replay

1. Poll for input

App

1.5 RnR tracer

Input trace archive

≥72 Hz
(<14 ms per iteration)

2. Simulate and render frame

3. Send frame to display

Poll performance counters (1 Hz)

Perf. monitor

Node

Experiment Setup

1. Poll for input

App

1.5 RnR tracer

Input trace archive

≥72 Hz
(<14 ms per iteration)

2. Simulate and render frame

3. Send frame to display

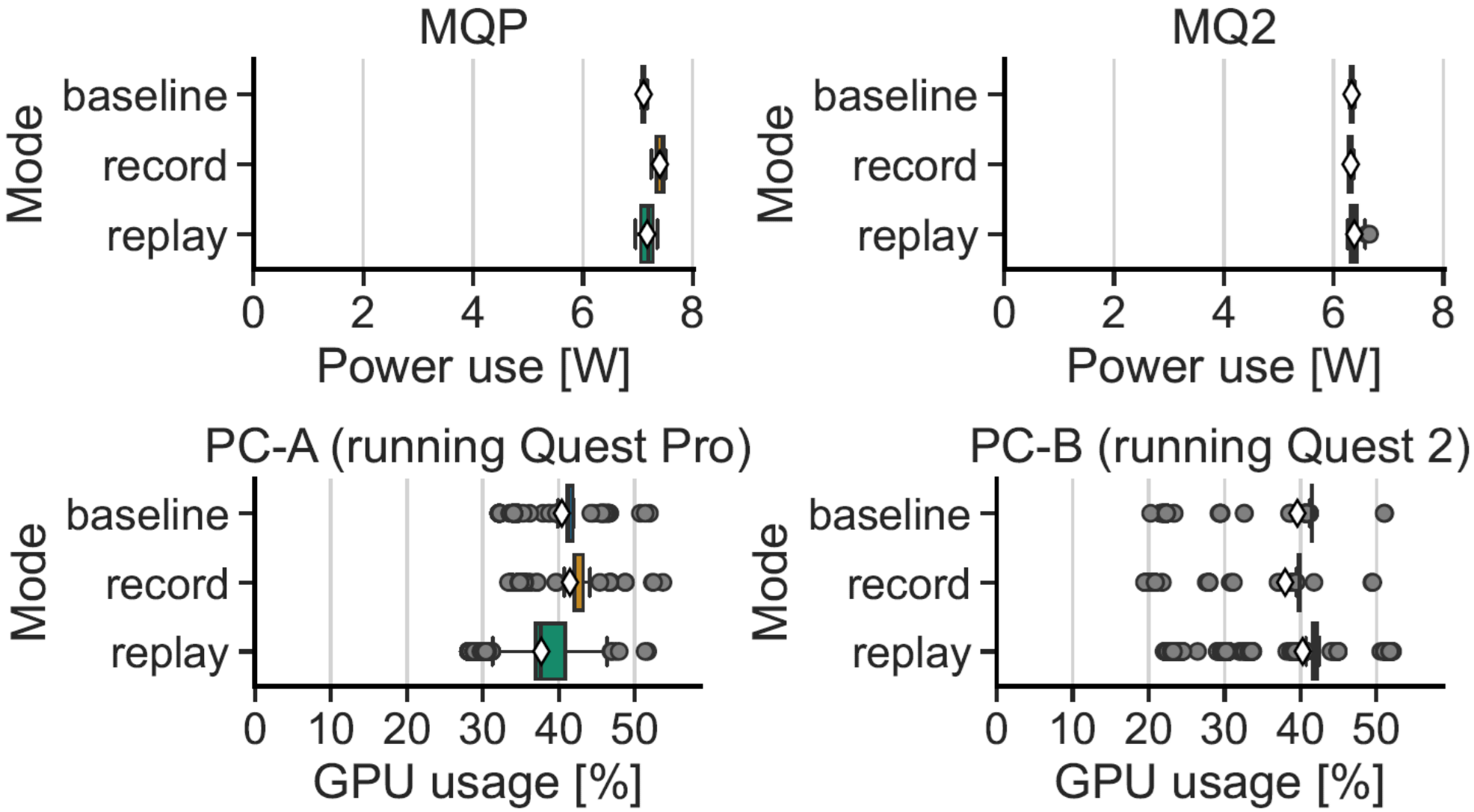
Poll performance counters (1 Hz)

Perf. monitor

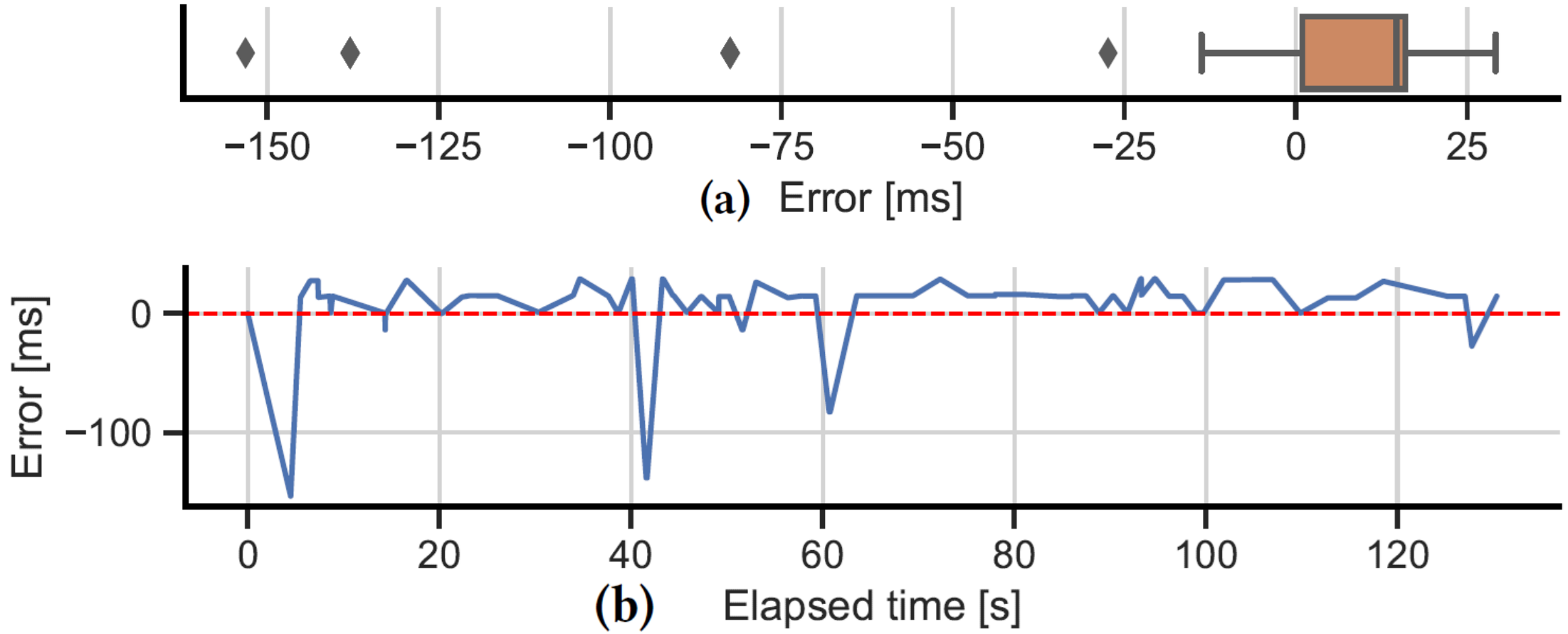
Network emulation

Node

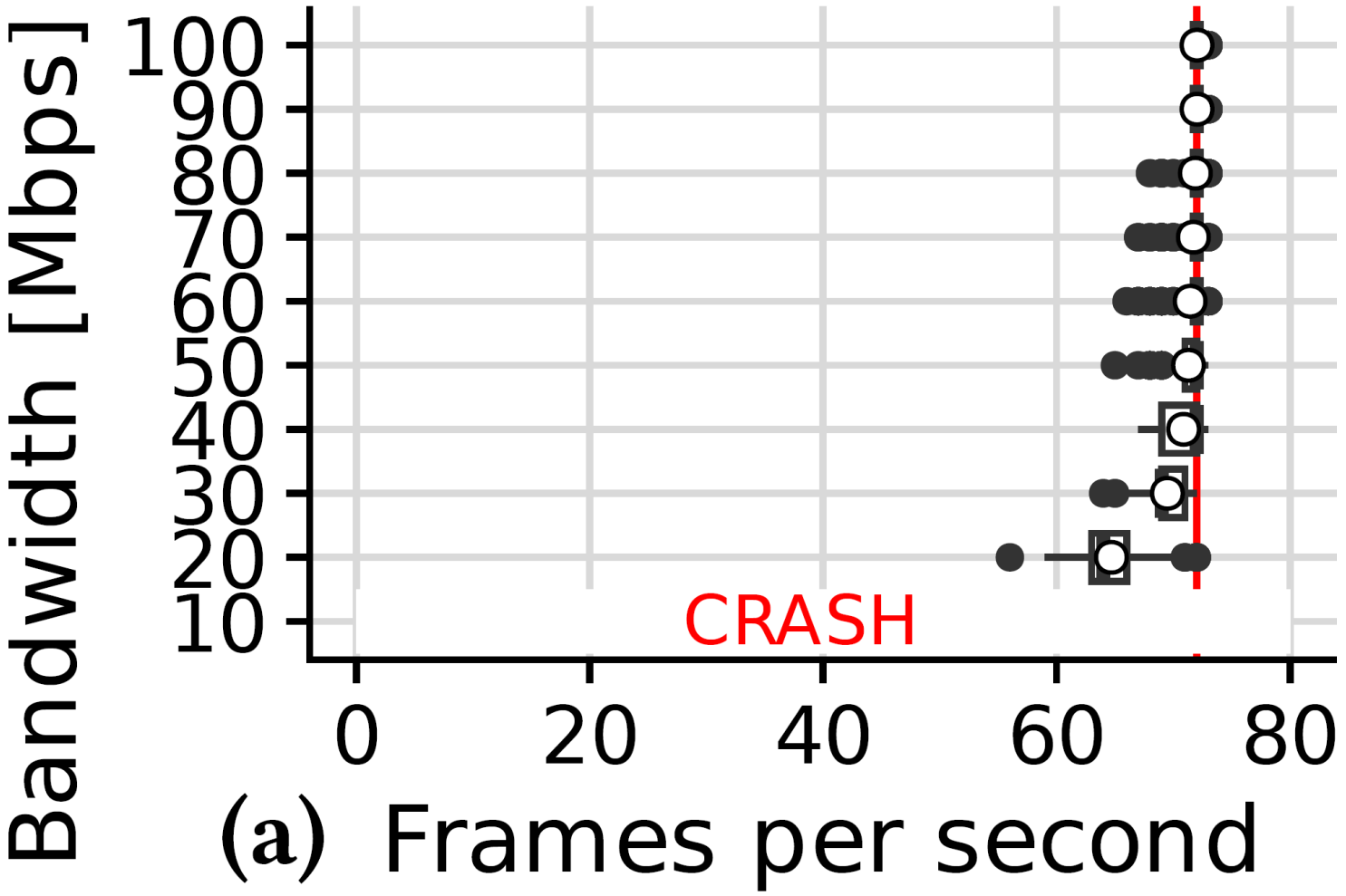
Record and Replay has low overhead



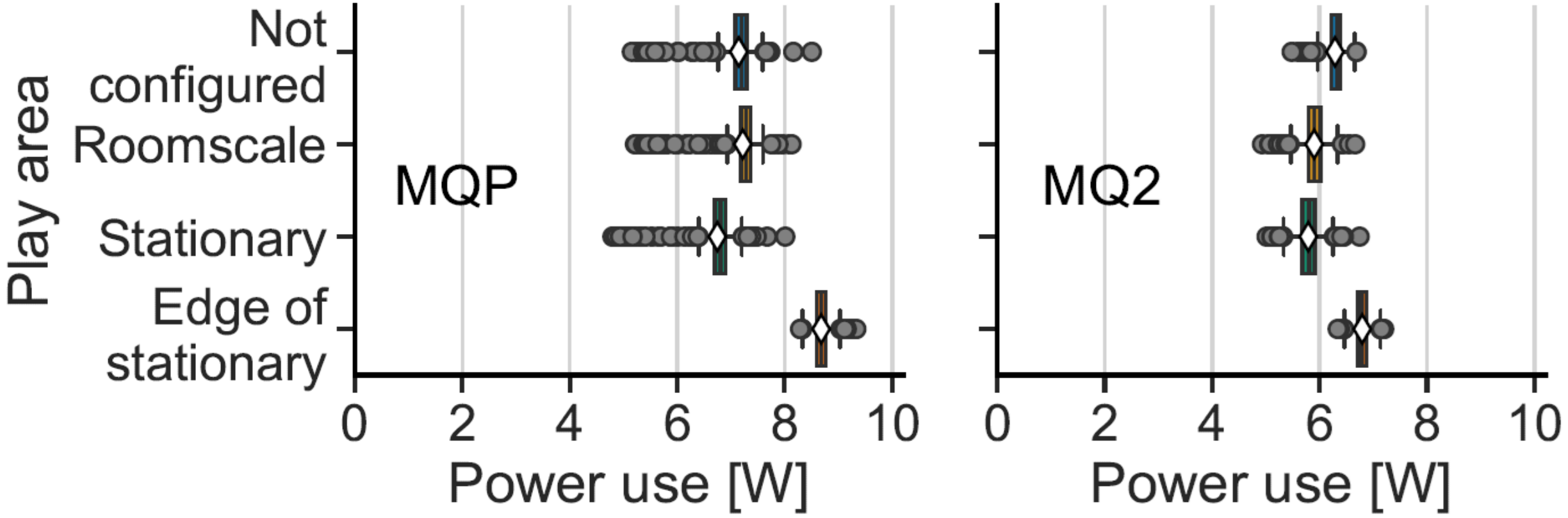
Record and Replay Input with High Timing Accuracy



VR streaming playable with (relatively) low bandwidth



Blending Reality Increases Power Use



Blending Reality Increases Power Use

Take-Home Message

1. The metaverse is an emerging ecosystem with **promising applications**
2. We have insufficient knowledge about design trade-offs and system behavior in the VR and metaverse ecosystem to overcome **frequent failures and performance degradations**
3. We address this challenge by working towards a **workload trace archive** for metaverse systems

Further Reading

Can My WiFi Handle the Metaverse? A Performance Evaluation Of Meta's Flagship Virtual Reality Hardware, Jesse Donkervliet, Matthijs Jansen, Animesh Trivedi, Alexandru Iosup, ICPE HotCloudPerf 2023

Meterstick: Benchmarking Performance Variability in Cloud and Self-hosted Minecraft-like Games, Jerrit Eickhoff, Jesse Donkervliet, Alexandru Iosup, ICPE 2023

Servo: Increasing the Scalability of Modifiable Virtual Environments Using Serverless Computing, Jesse Donkervliet, Javier Ron, Junyan Li, Tiberiu Iancu, Cristina L. Abad, Alexandru Iosup, ICDCS 2023

Dyconits: Scaling Minecraft-like Services through Dynamically Managed Inconsistency, Jesse Donkervliet, Jim Cuijpers, Alexandru Iosup, ICDCS 2021

Towards Supporting Millions of Users in Modifiable Virtual Environments by Redesigning Minecraft-Like Games as Serverless Systems, Jesse Donkervliet, Animesh Trivedi, Alexandru Iosup, HotCloud 2020

Extra Slides

Open in case of emergency

Our Society Benefits from Games

Take Minecraft

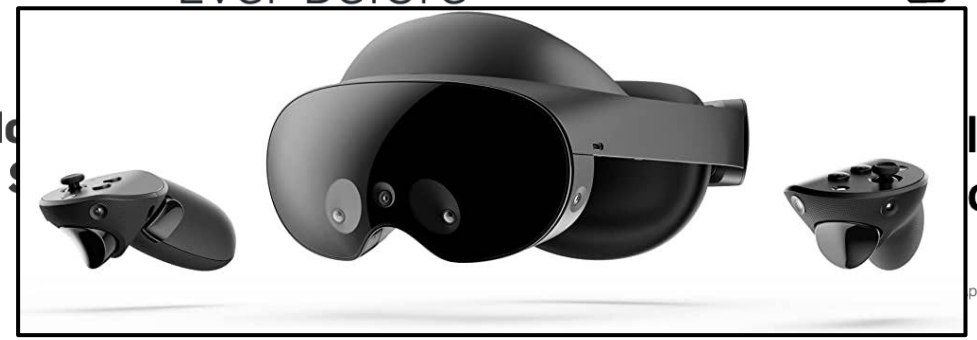
- Over **125 million people** play Minecraft every month
- **40,000+ mods**
- **100+ games "like M'craft."**

Generally Beneficial Features

- **Entertainment**
- Education
- Activism
- Social Interaction

students reconstruct Unesco world heritage sites Minecraft.

raft: Connecting More Players Than Ever Before



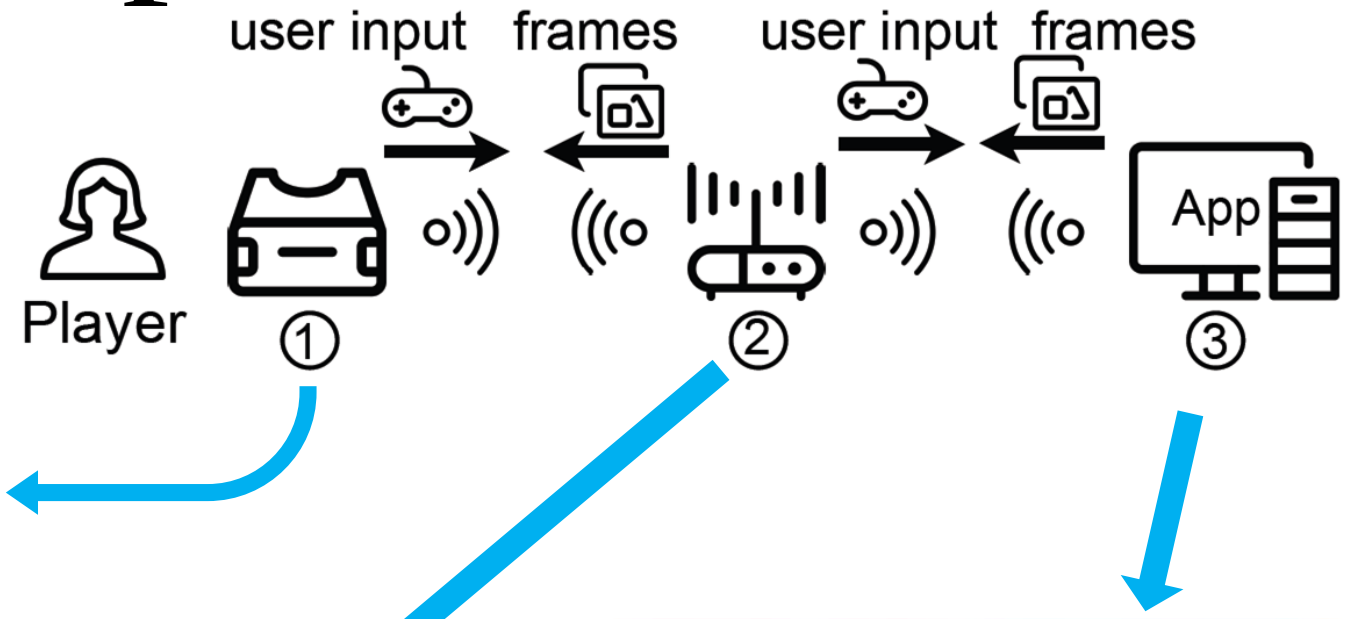
MINECRAFT

Idles to play Minecraft virtual
ck by Blockwest'

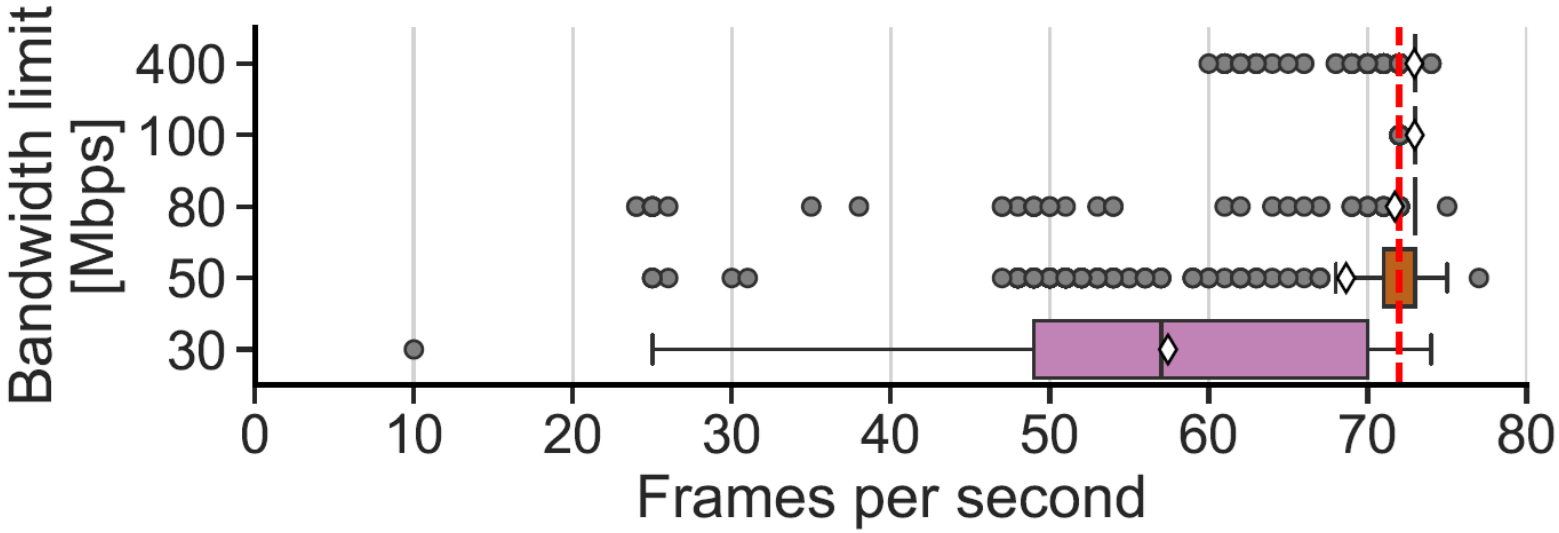
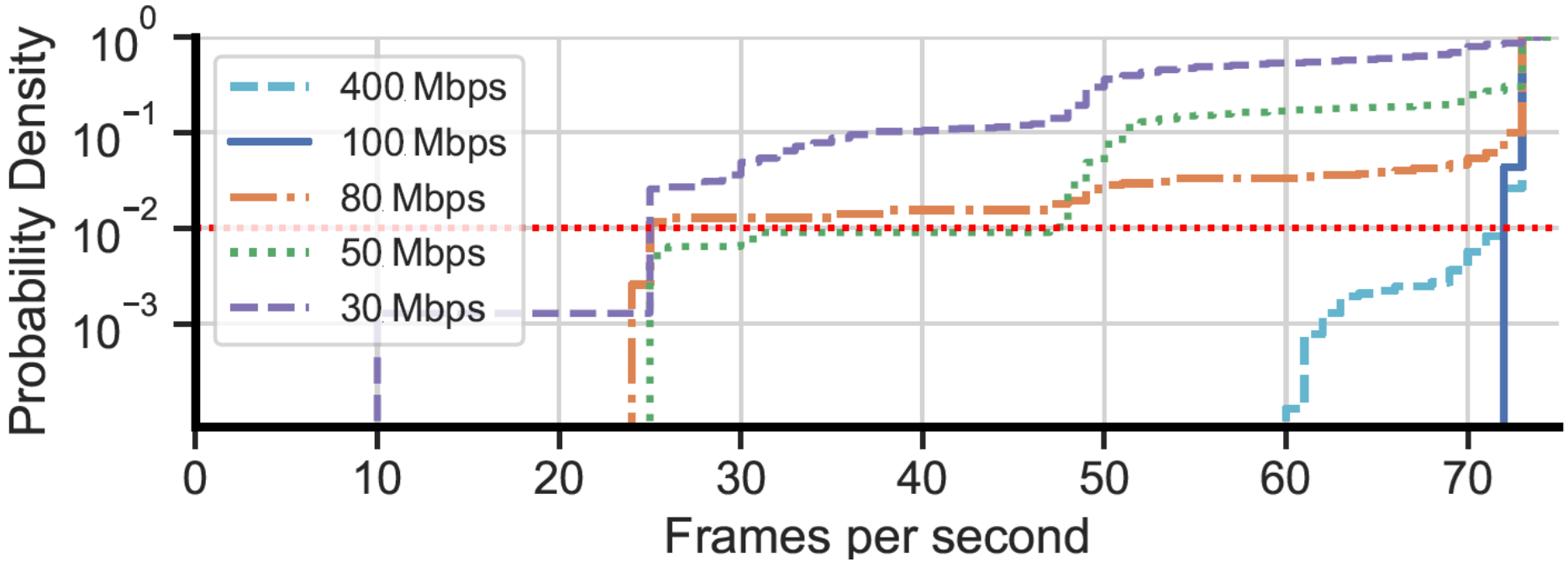
pr 22, 2020, 1:33pm EDT

Experiment Setup

Meta Quest Pro & Meta Quest 2



TP-Link Archer
AC1200
5GHz WiFi

Hardware	PC-A	PC-B
OS	Windows **11**	Windows **10**
CPU	AMD Ryzen 5 7600X	AMD Ryzen 5 7600X
GPU	GeForce RTX **3080**	GeForce RTX **4070**
WiFi	802.11ax	802.11ax

Bandwidth vs. Performance