FACULTY OF ENGINEERING AND ARCHITECTURE

DEPARTMENT OF INFORMATION TECHNOLOGY
IDLAB-IMEC

HURDLES AND OPPORTUNITIES TOWARDS ENABLING TRULY IMMERSIVE HOLOGRAPHIC-TYPE COMMUNICATION

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WE HAVE MOVED FROM STATIC TO DYNAMIC CONTENT…

Dozens feared dead in Iraq ferry disaster

Most of those on board the vessel that sank in a tourist area near Mosul could not swim, reports say.

MIDDLE EAST

New Zealand to ban military style weapons

PM Jacinda Ardern says gun owners must hand in affected weapons, in a bid to prevent mass shootings.

ASIA

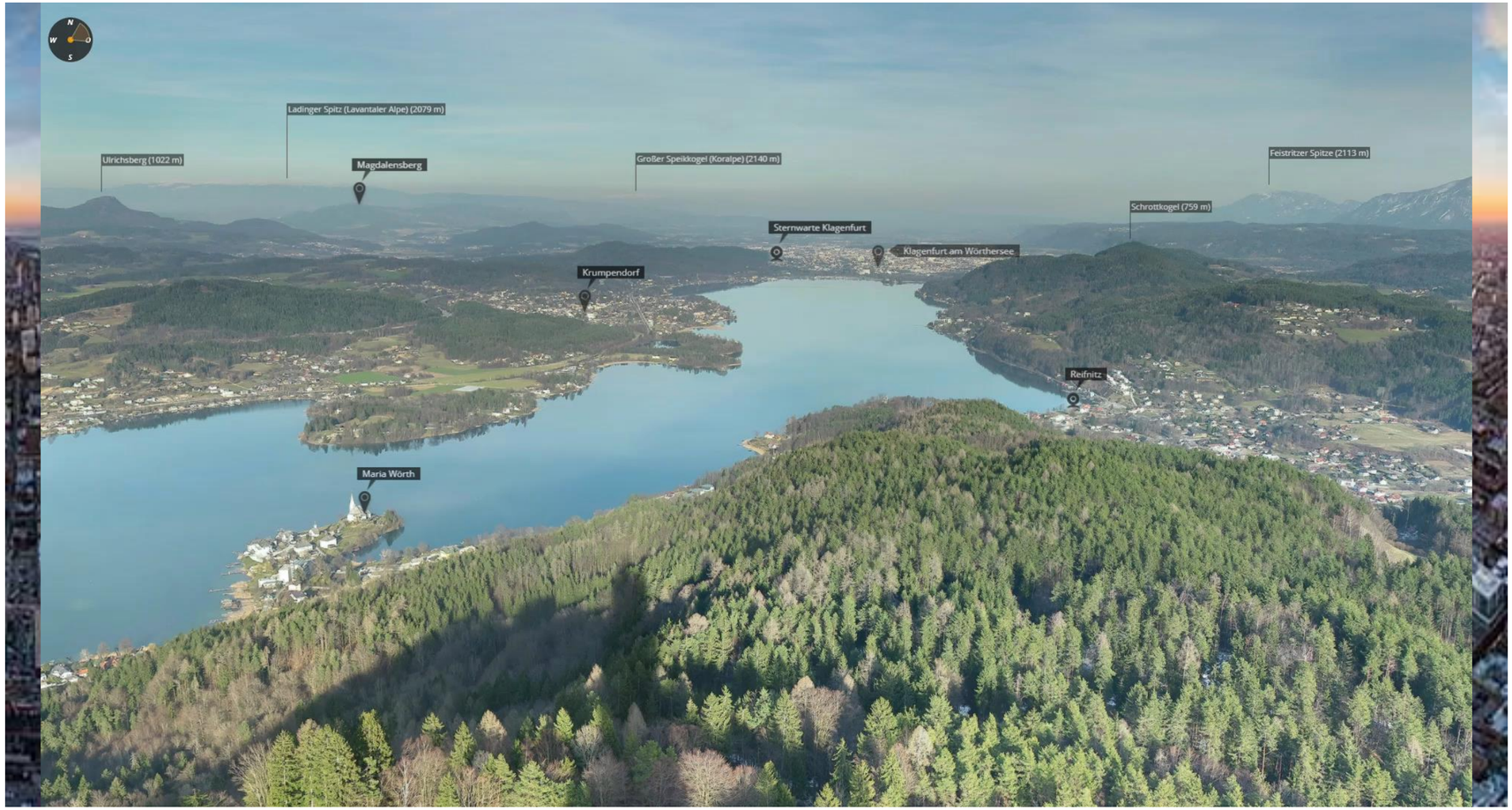
'It has become an inland sea'

The BBC's Fergal Keane assesses the devastation caused by Cyclone Idai in Mozambique.

AFRICA

… AND ARE MOVING FAST TOWARDS IMMERSIVE MEDIA

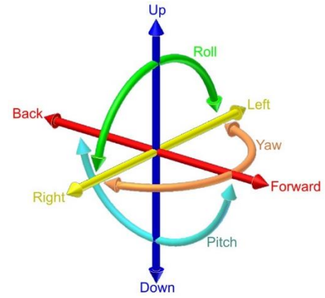
VIRTUAL REALITY (VR) COMES IN MANY FLAVORS



MOST VR USE CASES CONSIDER THREE DEGREES OF FREEDOM (3DOF)

SOME CONSIDER FIVE DEGREES OF FREEDOM (BUT NEVER CATCH ON)

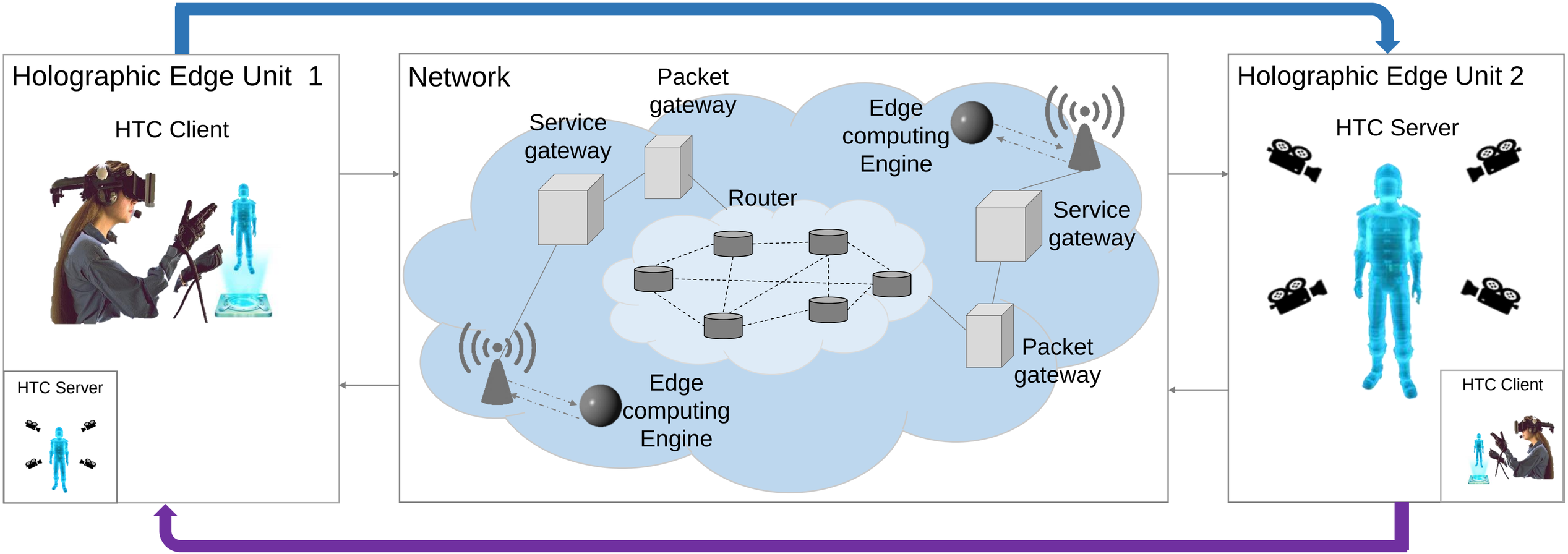
OTHERS ENVISION AN ENTIRELY NEW WAY OF DOING THINGS



- 6 Degrees of Freedom
- True Immersiveness:
  - Real-time interactivity
  - Ultra-high quality to avoid cybersickness

THE TRULY IMMERSIVE HOLOGRAPHIC TYPE COMMUNICATION END-TO-END SYSTEM

THE HOLOGRAPHIC TRANSMISSION CHAIN



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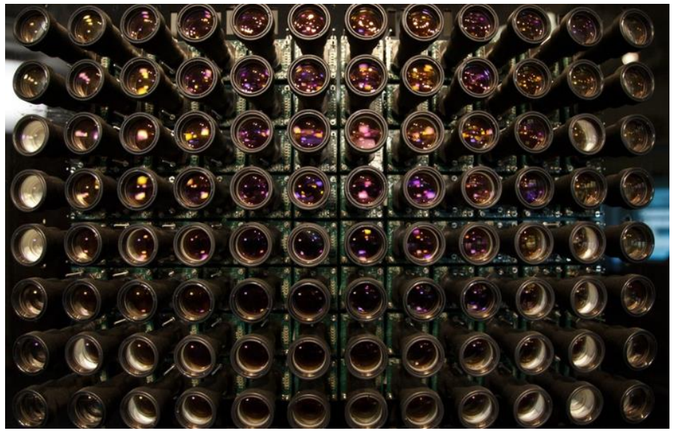
HOLOGRAPHIC CAMERAS AND RECEIVERS

Holographic Transmitters

RGB-Depth Cameras

360-Degree Cameras

Light-field Cameras

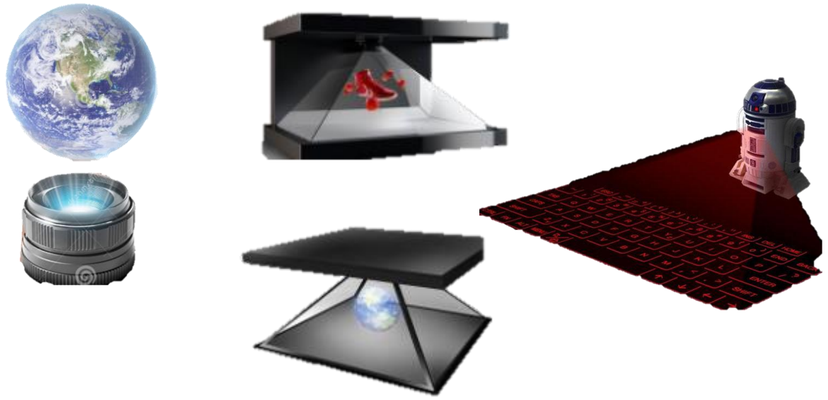


Holographic Receivers

Head Mounted Devices (HMD)

Holographic Displays

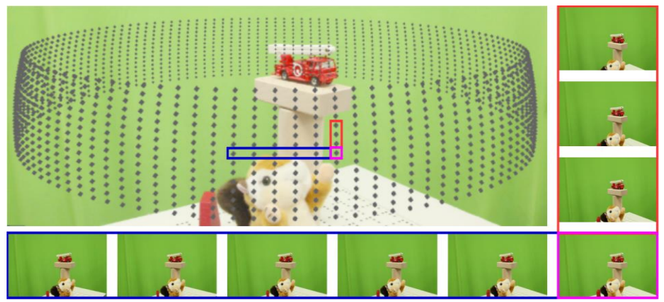
Holographic Projectors and Receivers



HOLOGRAPHIC RENDERING: LIGHT-FIELD VS POINT CLOUDS

Image-based solutions: Light-field Videos

- Large set of cameras: Images from different angles and views
- Massive amount of data:
  30° viewing, 10° tilt = 3300 separate images



Wijnants *et al.*, 2018

Volumetric-based solutions: Point clouds

- Less cameras, more optimized
- Sets of 3D volume pixels, or voxels

DYNAMIC POINT CLOUD OBJECTS




WHAT DOES TRUE IMMERSIVENESS REQUIRE FROM THE NETWORK INFRASTRUCTURES?

1. ULTRA-HIGH BANDWIDTHS REQUIREMENT

HD
(1080p)

1-5Mbps

360°(4K)

15-25Mbps

360° (16K)

100-500Mbps

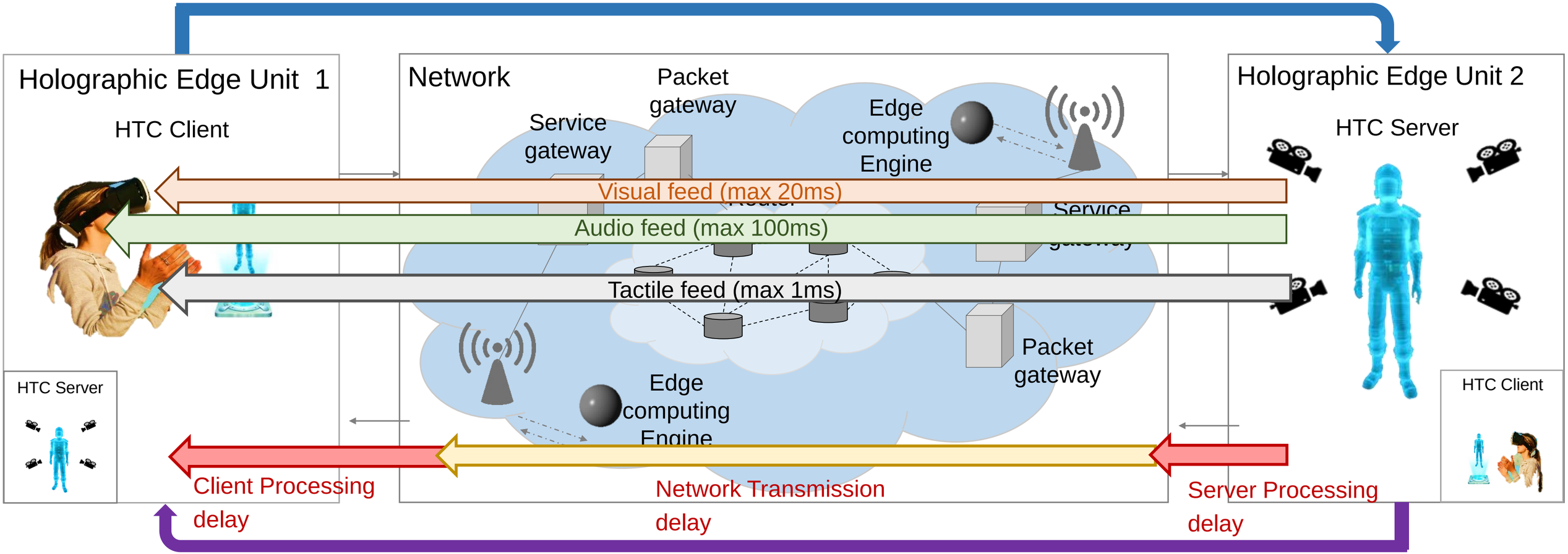
Hologram
(Point cloud)

0.5-2Gbps

Hologram
(Light field)

100Gbps-2Tbps

2. ULTRA-LOW LATENCY VS ULTRA-HIGH RELIABILITY



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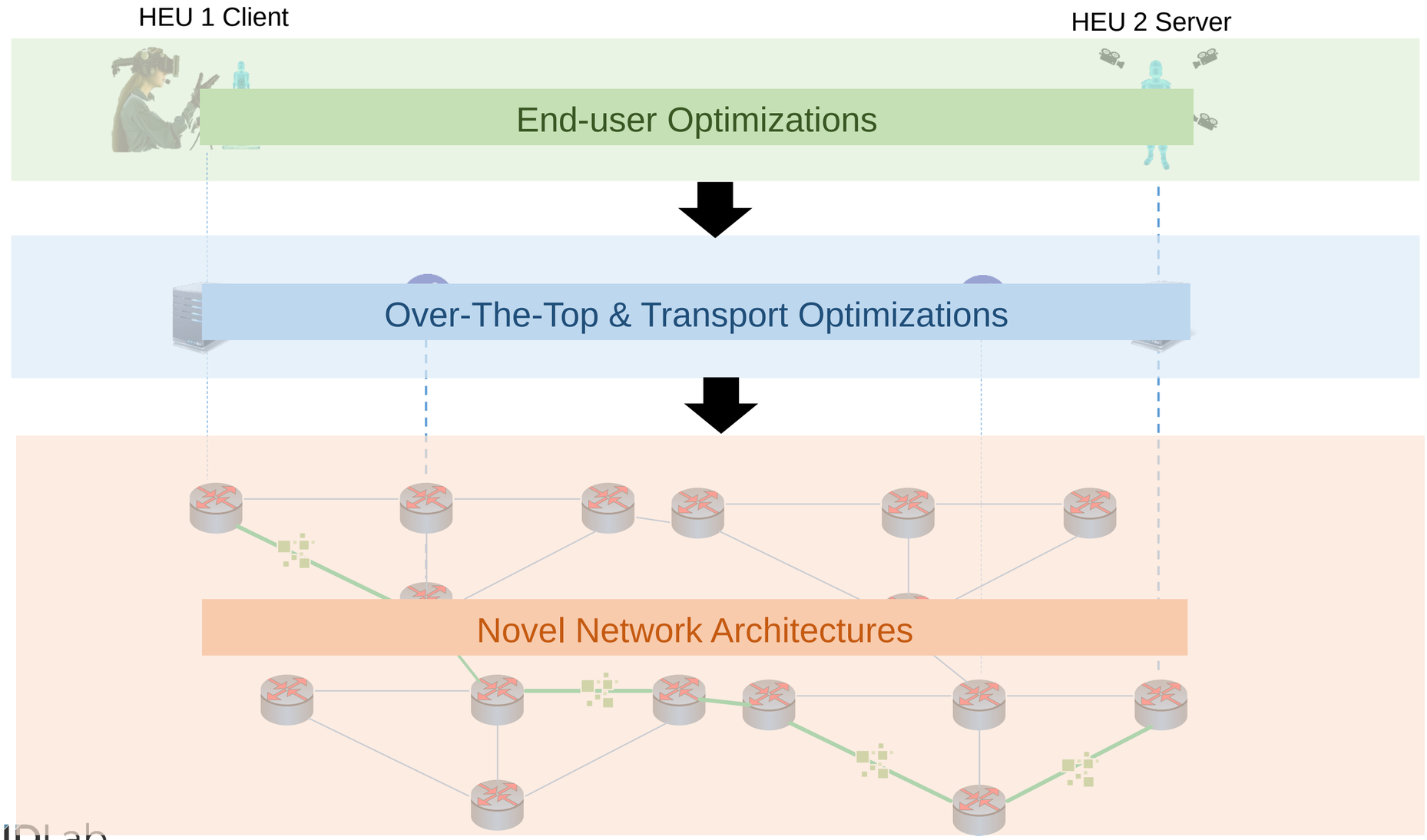
3. SYNCHRONIZATION OF STREAMS

Synchronized

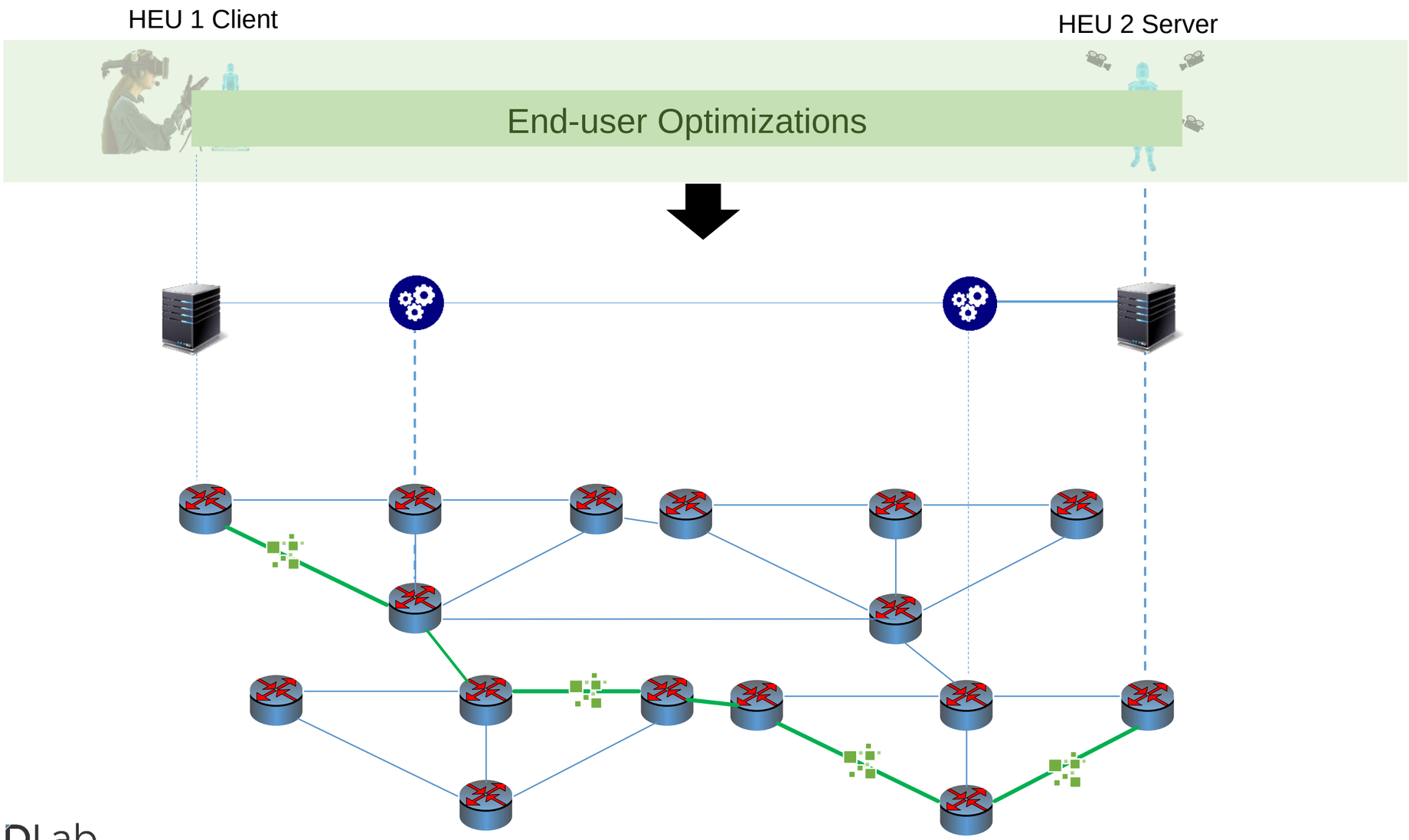
Desynchronized

HOW TO ACHIEVE TRULY IMMERSIVE HOLOGRAPHIC TYPE COMM.? A CROSS-LAYER APPROACH

TRULY IMMERSIVE HTC: A CROSS-LAYER APPROACH



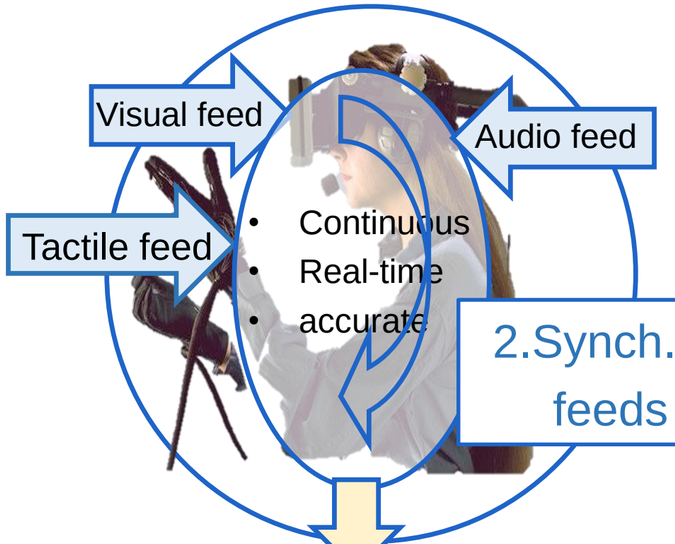
A CROSS-LAYER APPROACH: END-USER



END-USER OPTIMIZATONS

Client-side Optimizations

1.Viewport Prediction



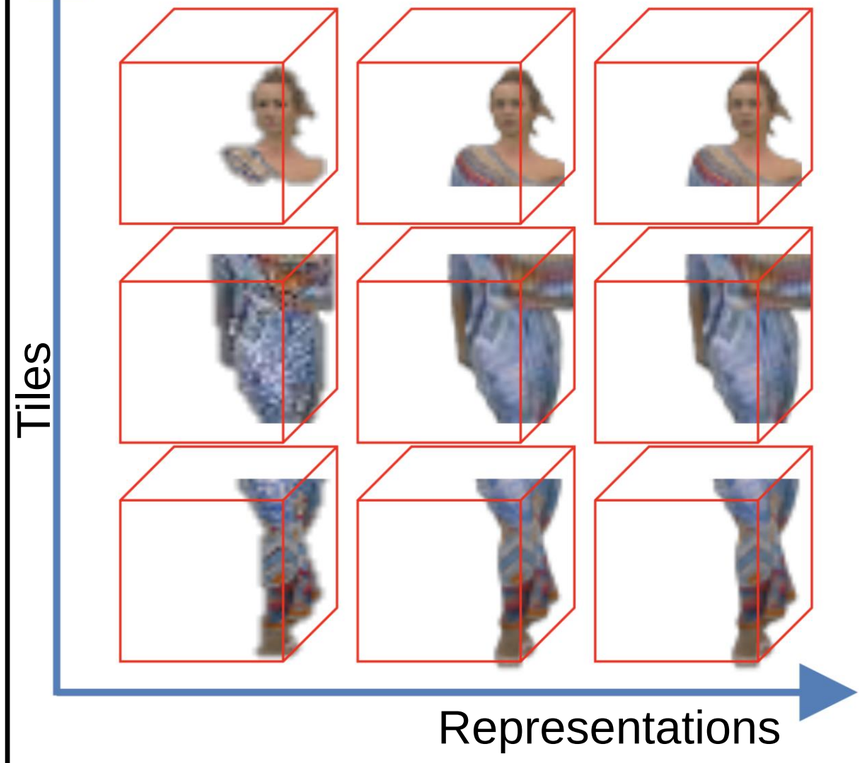
2.Synch. of feeds

3.QoS/QoE assessment

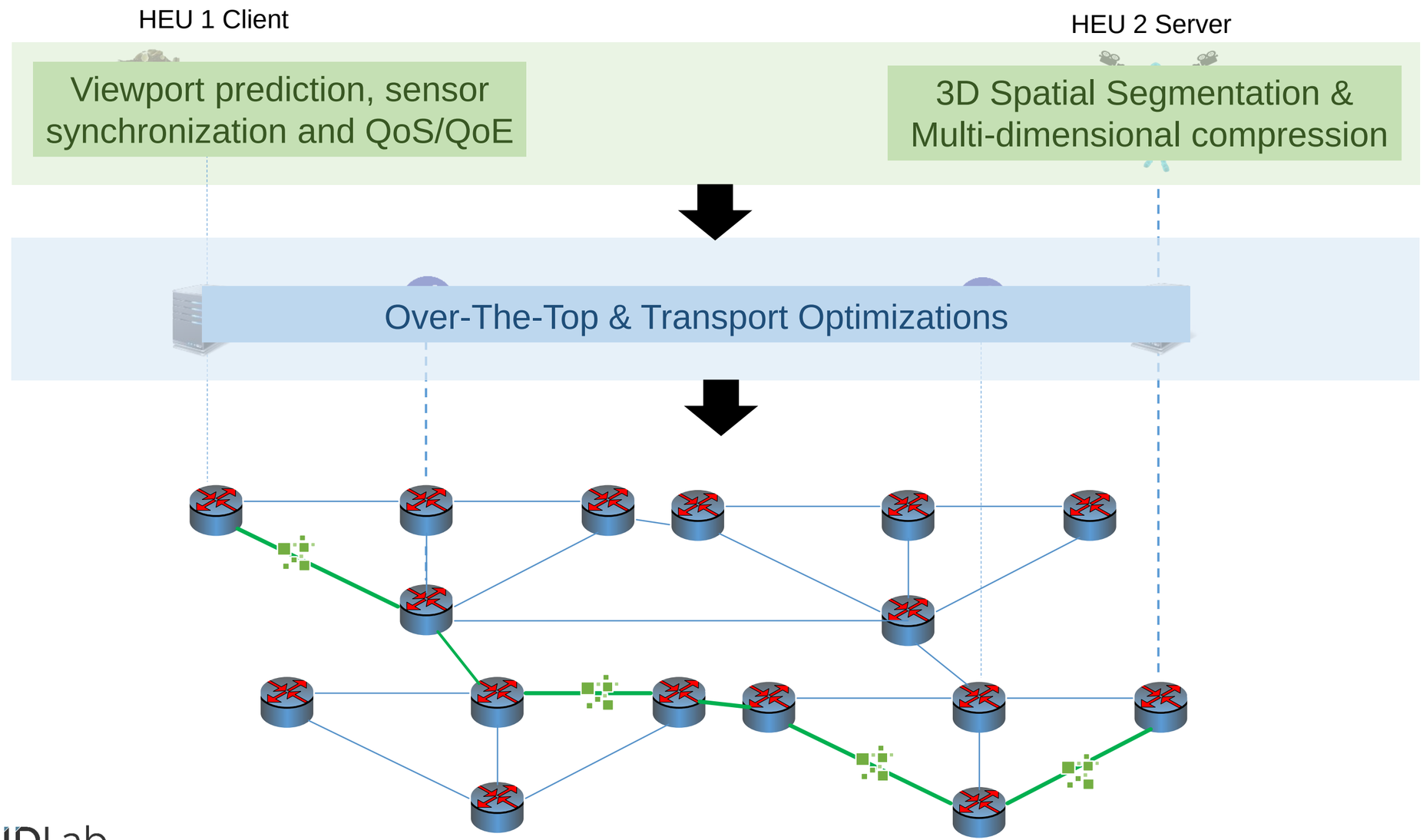
Viewpoint info & Quality

Server-side Optimizations

3D tiling and Multiple representations

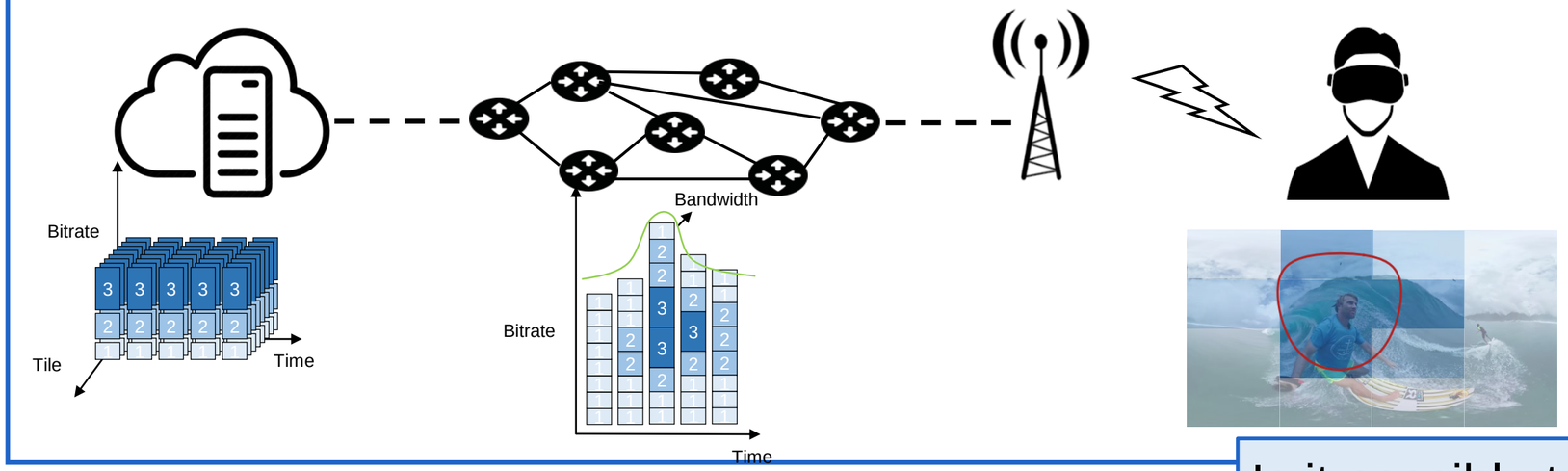


A CROSS-LAYER APPROACH: TRANSPORT



CURRENT VIDEO TRANSMISSION: QUALITY VS DELAY

HTTP ADAPTIVE STREAMING: QUALITY OPTIMIZATION



☺ Quality and Bandwidth optimization

😐 Segmentation: no life

☹ Processing, buffering and protocol overhead: no real-time

Is it possible to get the best of both worlds?

RTP/UDP STREAMING: LATENCY OPTIMIZATION

RTP/UDP streaming

WebRTC & QUIC: Browse-based real time streaming

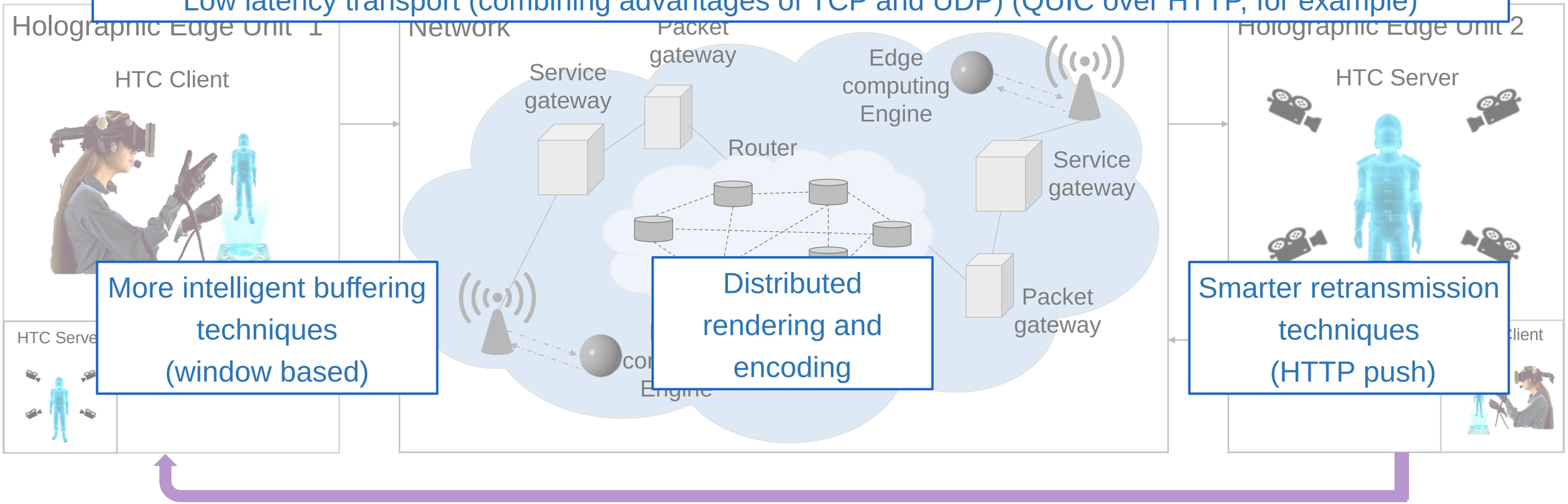
☺ Latency optimization

😐 Very limited quality control -> problem for HTC

☹ Very low resilience (packet loss prone)

OVER THE TOP & TRANSPORT OPTIMIZATIONS

Low latency transport (combining advantages of TCP and UDP) (QUIC over HTTP, for example)



More intelligent buffering techniques (window based)

Distributed rendering and encoding

Smarter retransmission techniques (HTTP push)

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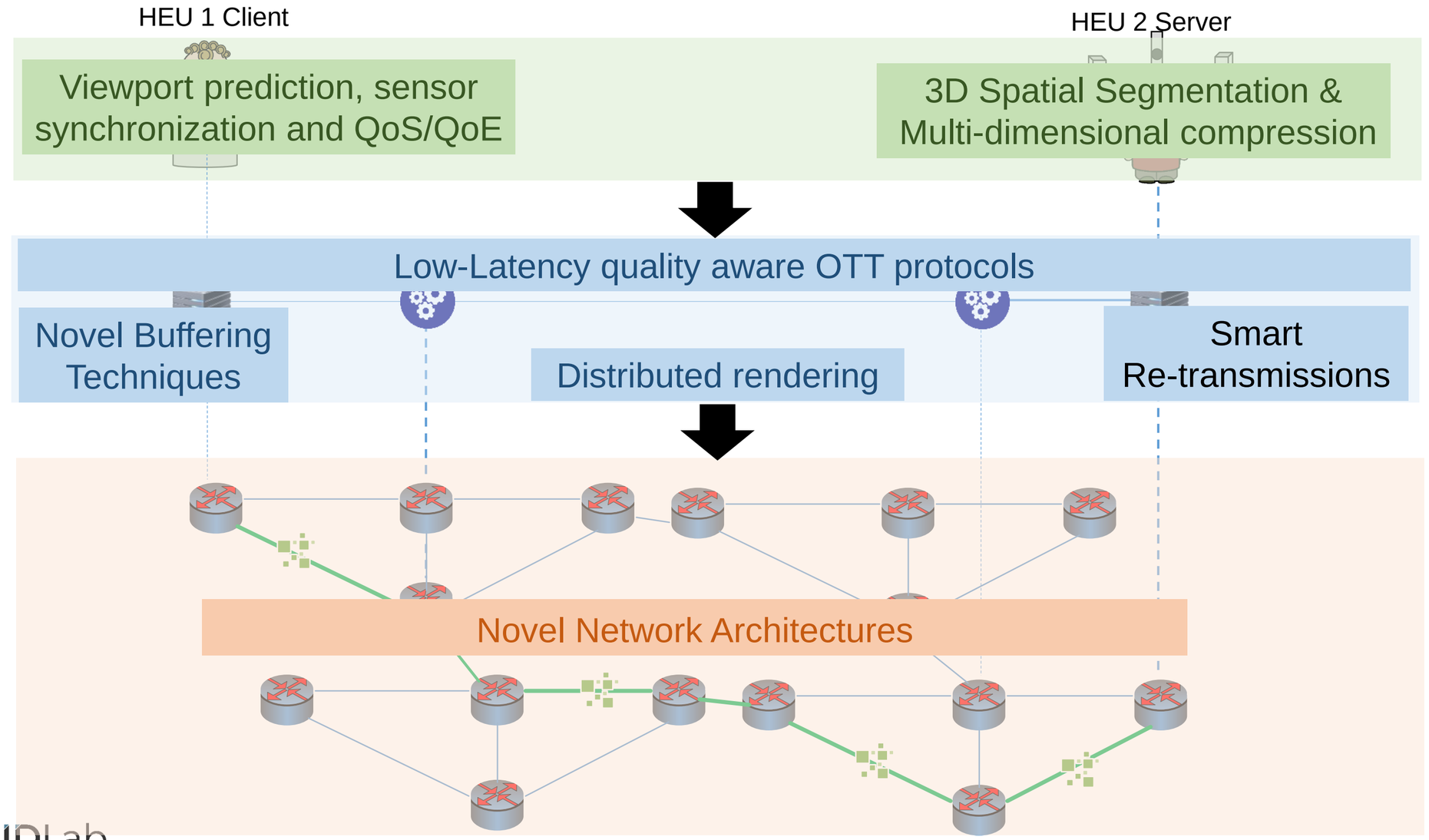
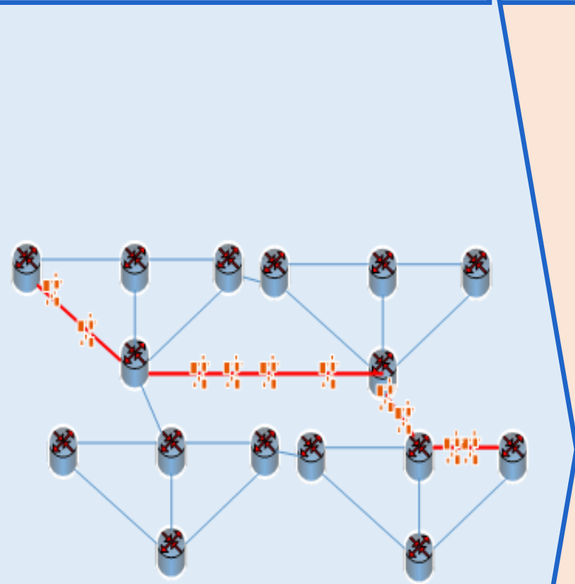
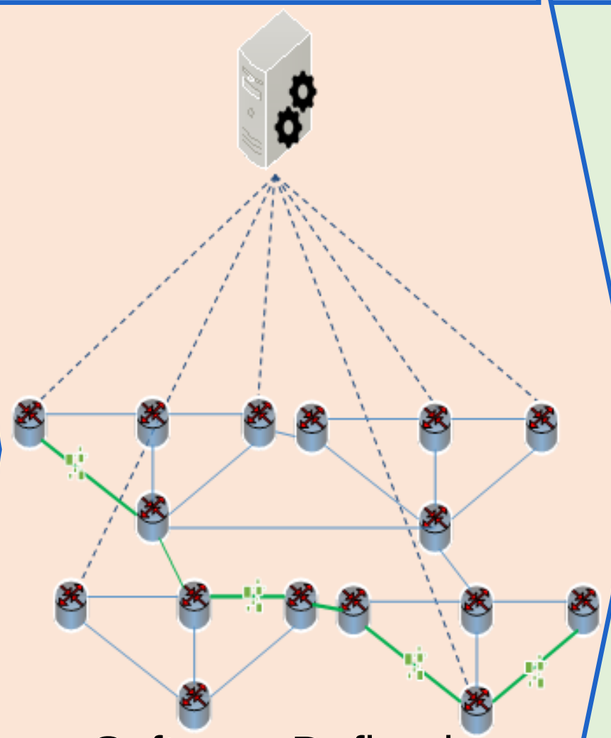
TRULY IMMERSIVE HTC: A CROSS-LAYER APPROACH



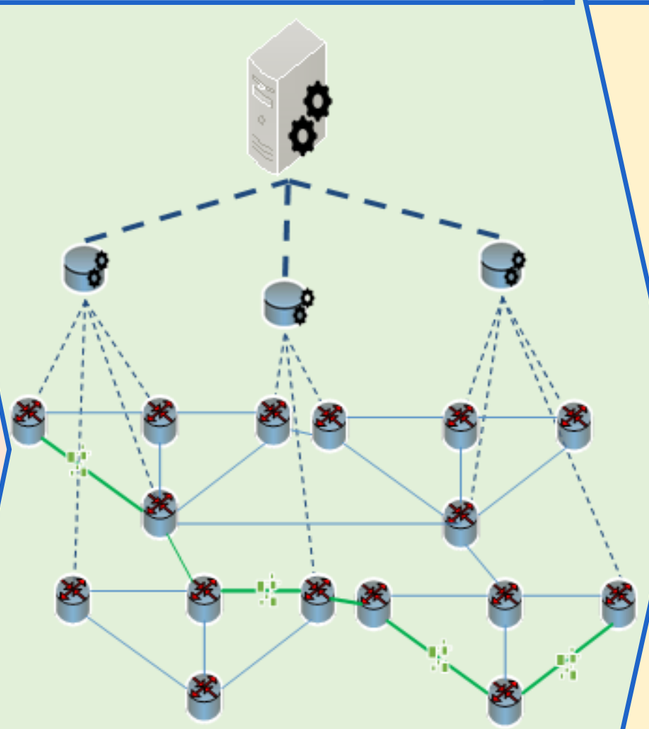
TOWARDS FULLY DECENTRALIZED NETWORKS…



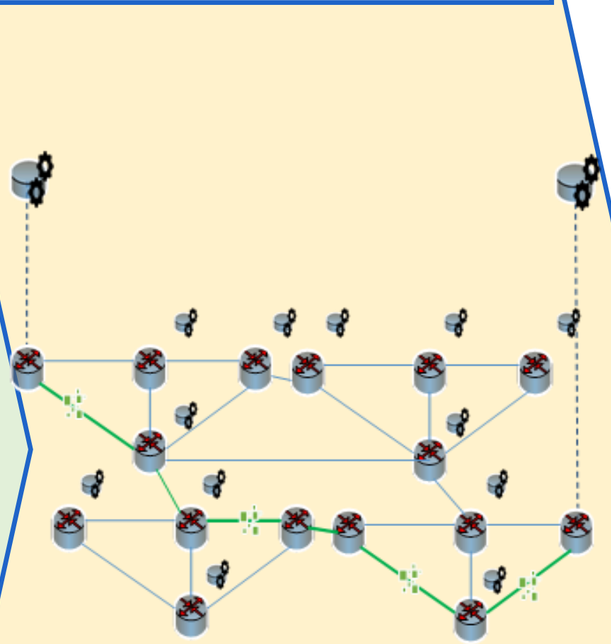
Current network infrastructure



Software Defined networks

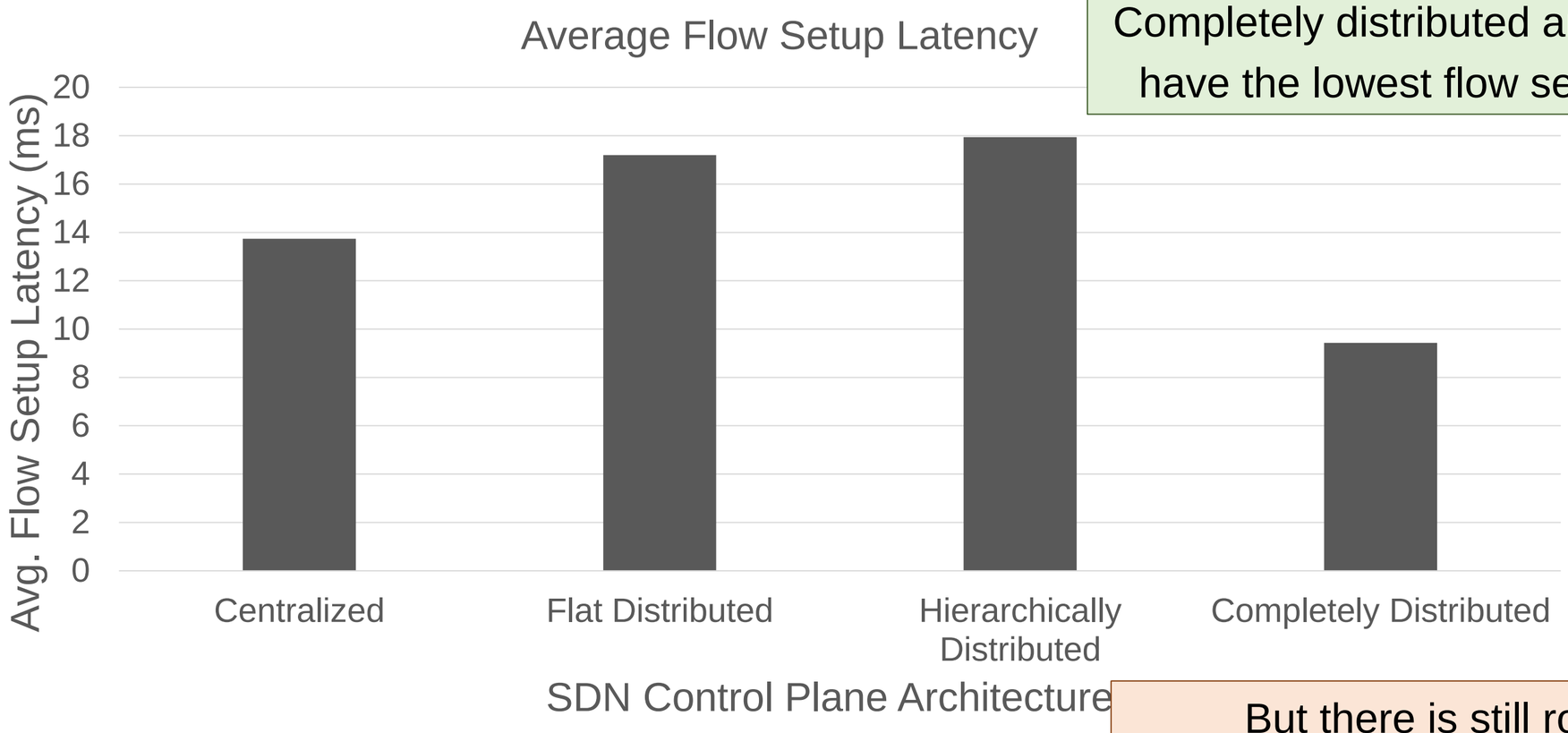


Hierarchically decentralized SDN



SDN with logically (&completely) decentralized controller

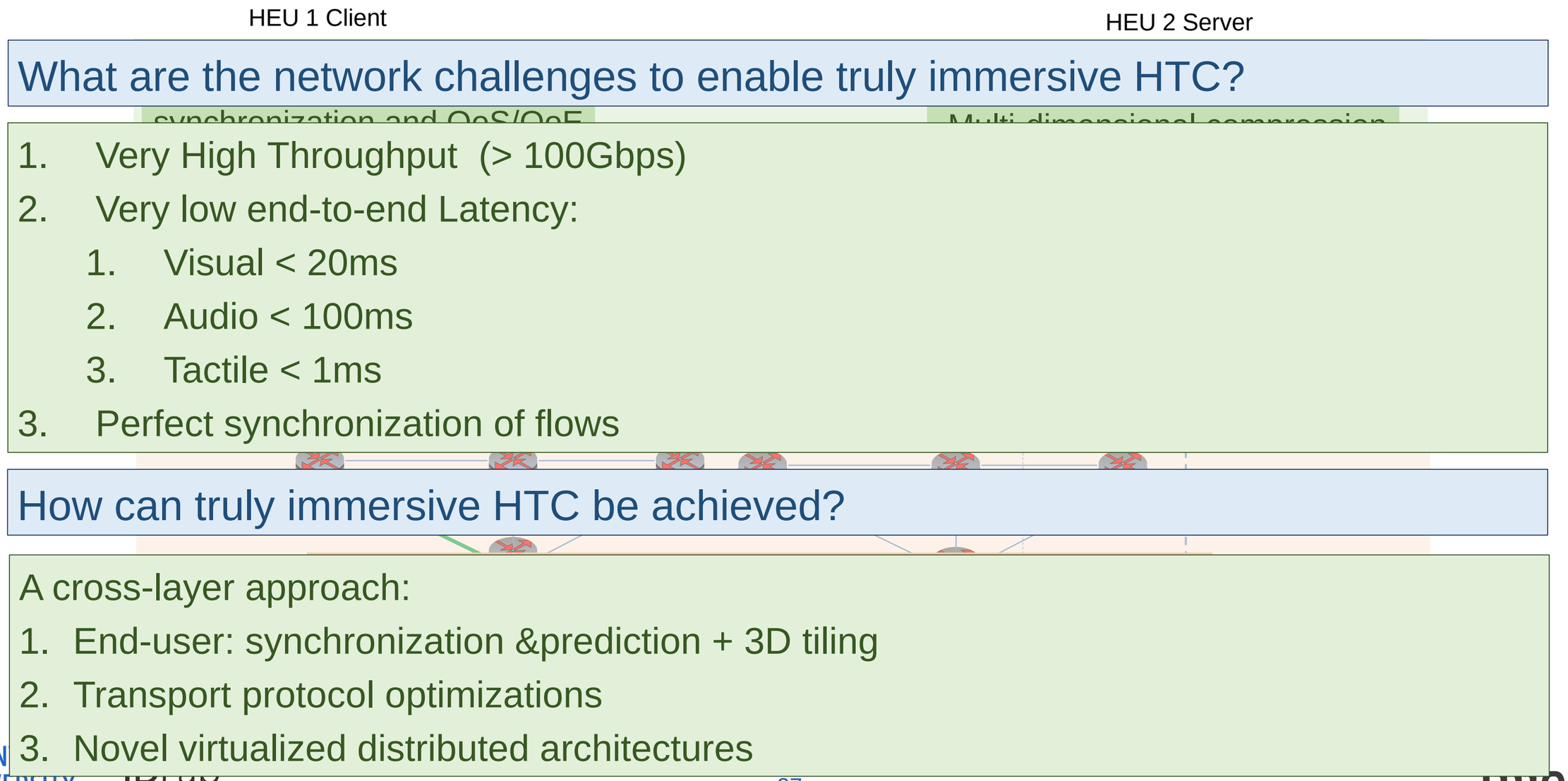
FLOW SET-UP LATENCY ANALYSIS FOR DIFFERENT SDN ARCHITECTURES



Completely distributed architectures have the lowest flow setup delay!

But there is still room for improvement

CONCLUSIONS



What are the network challenges to enable truly immersive HTC?

1. Very High Throughput (> 100Gbps)
2. Very low end-to-end Latency:
    1. Visual < 20ms
    2. Audio < 100ms
    3. Tactile < 1ms
3. Perfect synchronization of flows

How can truly immersive HTC be achieved?

A cross-layer approach:

1. End-user: synchronization &prediction + 3D tiling
2. Transport protocol optimizations
3. Novel virtualized distributed architectures

Thank you for your attention!

Any questions or comments?