6G NEXT

TOWARDS 6G SPLIT COMPUTING NETWORK APPLICATIONS USE CASES AND ARCHITECTURE

SERGIY MELNYK

6G NEXT – NATIVE EXTENSIONS FOR XR TECHNOLOGIES

- What are the demanding applications of the future?
    - HoloCom - Holographic Communication
    - Smart Drones
- What are the technologies to cope with the requirements?
    - High speed backbone with split computing capability
    - Low-Latency Reliable Mobile Communications
    - Convergence of Computing and Communication

SMART DRONES - ANTI COLLISION SYSTEM

6G.NeXt

6G NeXt is going to implement a new kind of Anti Collision System

Mission:

- Observing the traffic situation and **detecting / predicting dangerous situations** in the vicinity of an aerodrome
- **Calculate and fly the exit trajectory** in case of near miss
- **Calculation** of the trajectory **is off-loaded** to the most appropriate part of cloud (split computing)

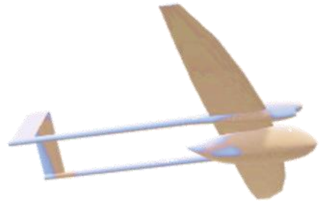
Innovation:

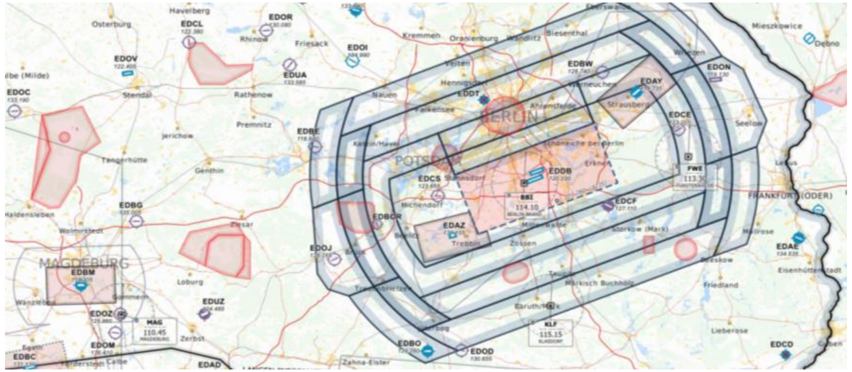
Current TCAS

- Pilots get a warning and in some situations **recommendation** to descend or to climb
- It is still in the **responsibility of the pilot** to steer the UAS/ airplane hopefully in the right way

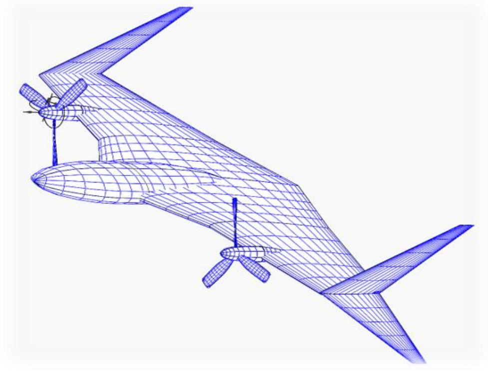
New method

- Our new 6G-based TCAS **calculates exact flight routes** and **controls drones actively** by taking aerodrome traffic into account
- The calculation of the flight way **is off-loaded to the most appropriate part of cloud**





DIGITAL TWIN OF UAVS



Calculation of trajectories requires a digital representation of every drone within the Anti-Collision System with all relevant parameters.

This enables simulation of critical situations in a virtual space

- Research on anti collision algorithm with fast moving UAVs
- Study on latency and reliability in 5G/6G networks in high-speed situations
- Research on conflict situations between slow- and fast-moving UAVs.

- The Smart Drone application adds dynamic change in availability of connectivity and CPU need, (GPU) power and low latency in processing and transmission
-

→ **computing and communication grow together**

EDGE-TO-CLOUD SERVERLESS PLATFORM

Compute: based on Function-as-a-Service (FaaS)

- Parallel invocations handled elastically
- Pay-as-you-go → application service only needs resources while it is running (resource-conscious at the edge)

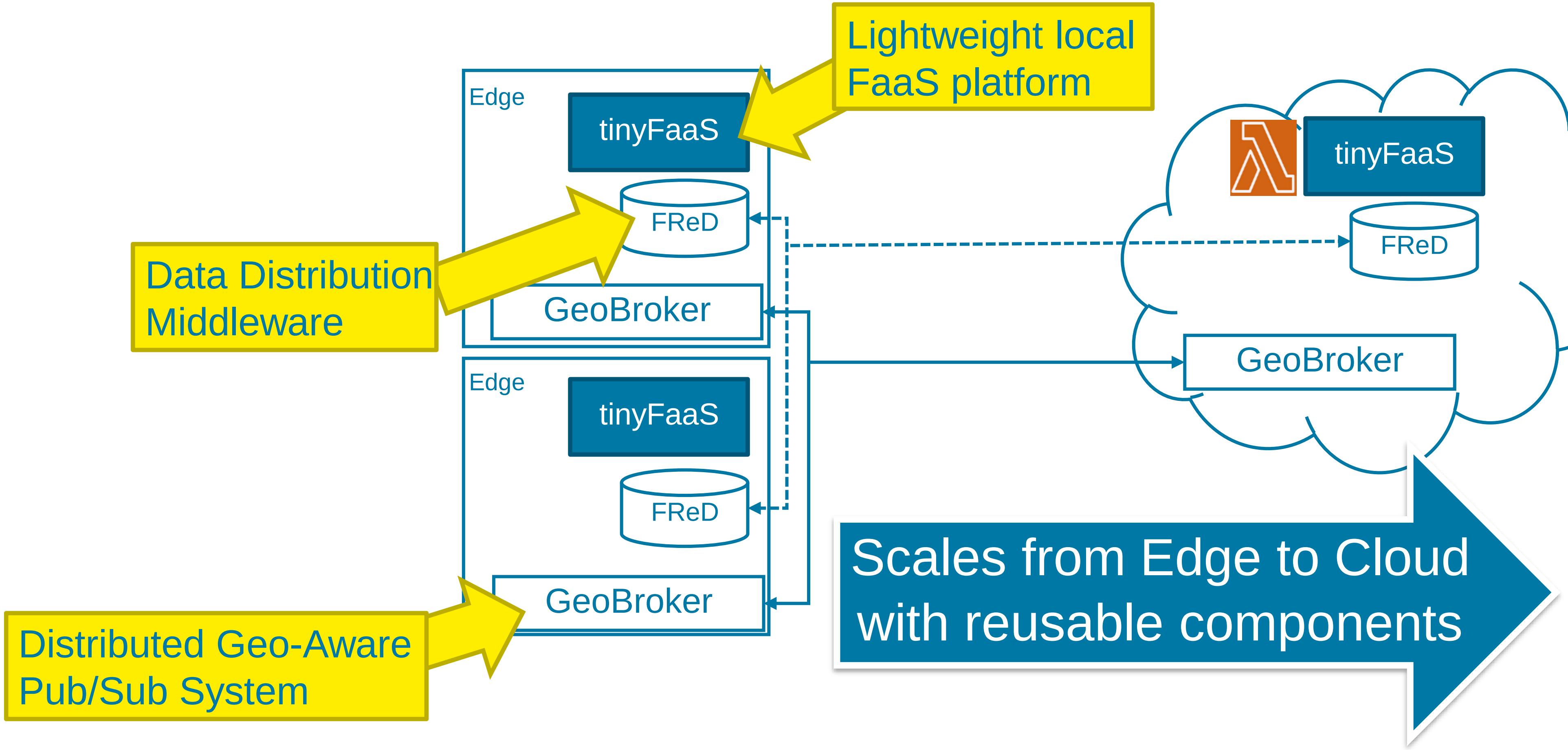
Data: State decoupled from compute

- Compute services can be scaled infinitely without consistency issues (handled by data platform)
- Data is distributed across regions efficiently (can be replicated with consistency)
- Data persistence is cheap at the edge (no running services needed)

Communication: low-latency publish/subscribe system

- Low-latency communication still needed
- Pub/sub paradigm makes integrating heterogeneous services easy
- ”geo-aware” pub/sub limits message dissemination

EDGE-TO-CLOUD SERVERLESS PLATFORM



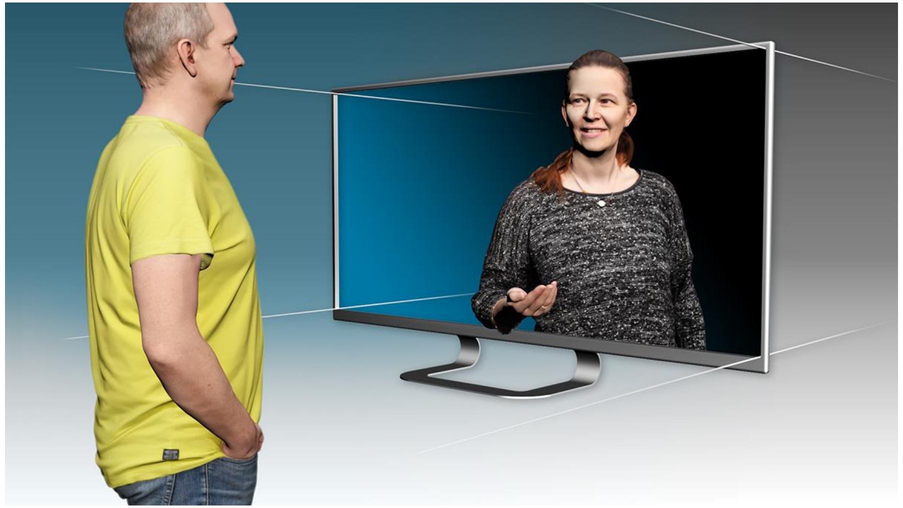
HOLOCOM
FUTURE COMMUNICATION SERVICE

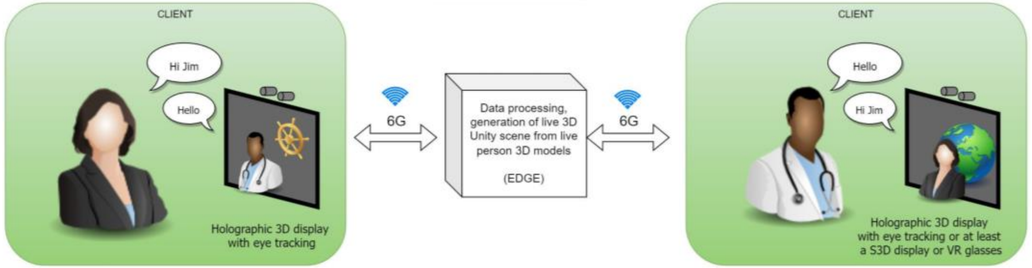
6G NeXt is going to implement a HOLOGRAPHIC 3D Chat with:

- **Natural eye focus**
  No glasses required. Eye accommodation (AKA eye focus) is not fixated on the physical display as in pure Stereoscopic 3D displays.

- **Natural depth**
  Image content is properly placed in space by real holograms – and crisply sharp at any depth.

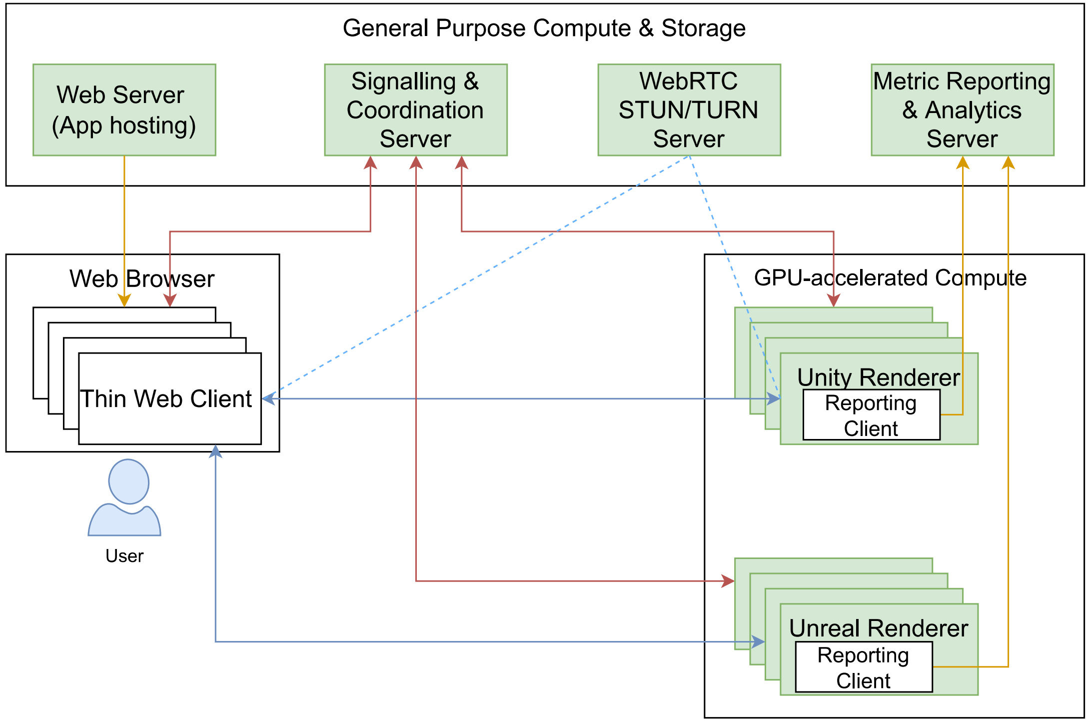
- **Natural viewing**
  No difference to natural viewing for the human visual system – same depth cues provided.



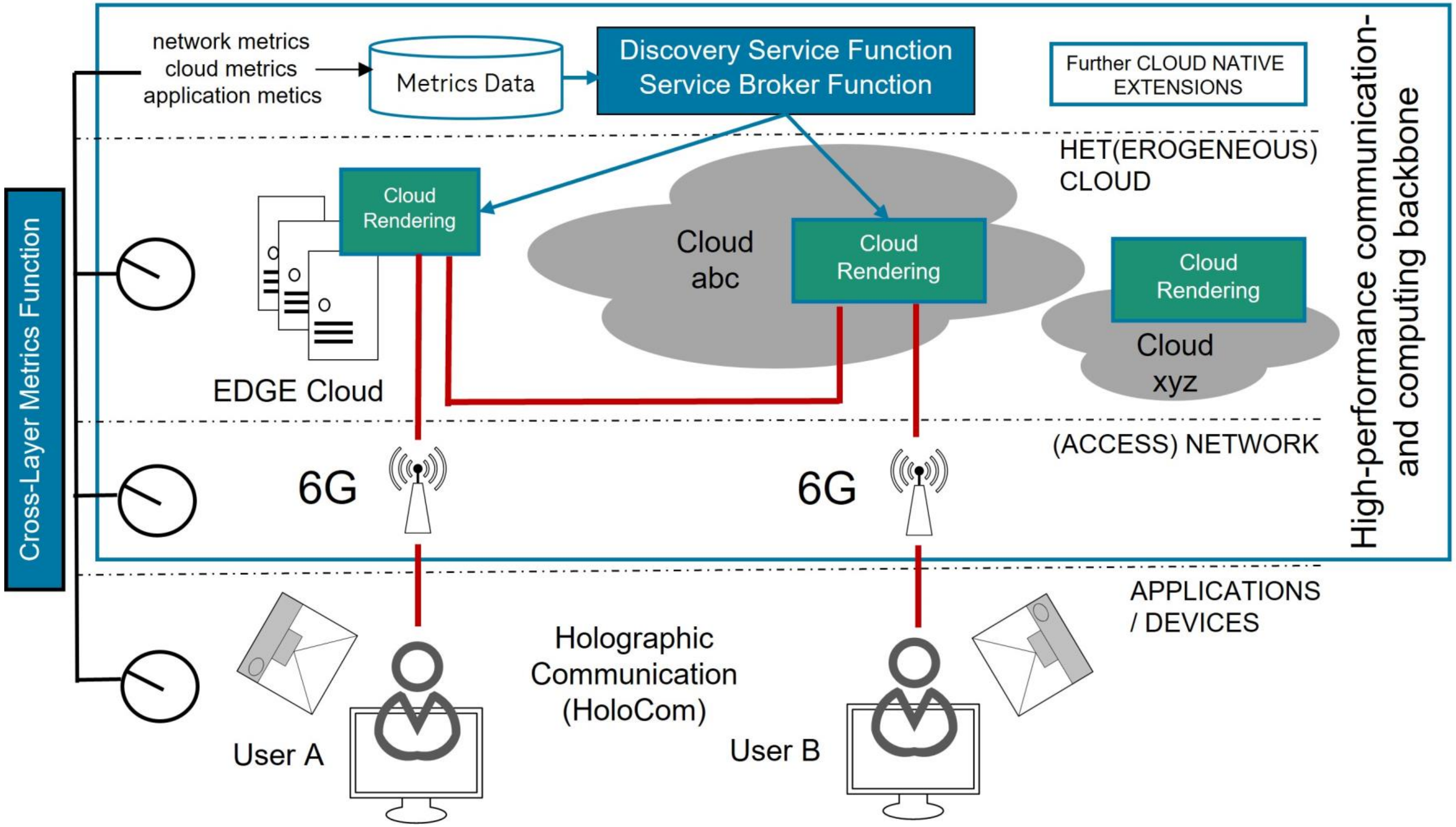


XR SPLIT RENDERING

- Viewport Rendering and AI Processing tasks are crucial components affecting the 3D experience. Rendering photorealistic content requires advanced graphical processing which is not available on most consumer devices.
- Split Rendering solves this issue by offloading complex rendering and processing task to the network.
- Workloads must run efficiently on-device at low latency
  - Minimizing motion to photon latency is crucial for immersion



COMPUTING- AND NETWORK ARCHITECTURE

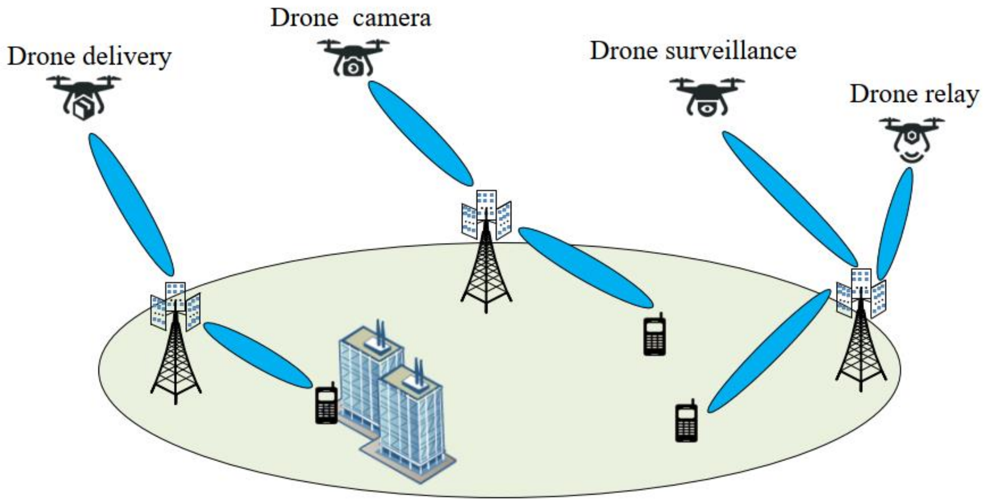


IMMERSIVE MEDIA COMMUNICATION QUALITY OF EXPERIENCE

- User experience is central factor for real-time immersive media communication
  - Higher values of QoS not necessarily ensure higher values of QoE
  - Human perception is sensitive to certain display errors
  - User aspects must be included in the evaluation of HoloCom
- Subjective as well as objective metrics will be used for evaluation
  - Subjective measures include questionnaires related to co-presence, social presence, immersion,.
  - Overall mean opinion score will be computed
  - Conversational and behavioral data of the participants will be recorded for indirect evaluation of user experience
- Objective measures will be computed to evaluate 3D rendering, encoding and decoding of conversational partner

RADIO ACCESS NETWORK

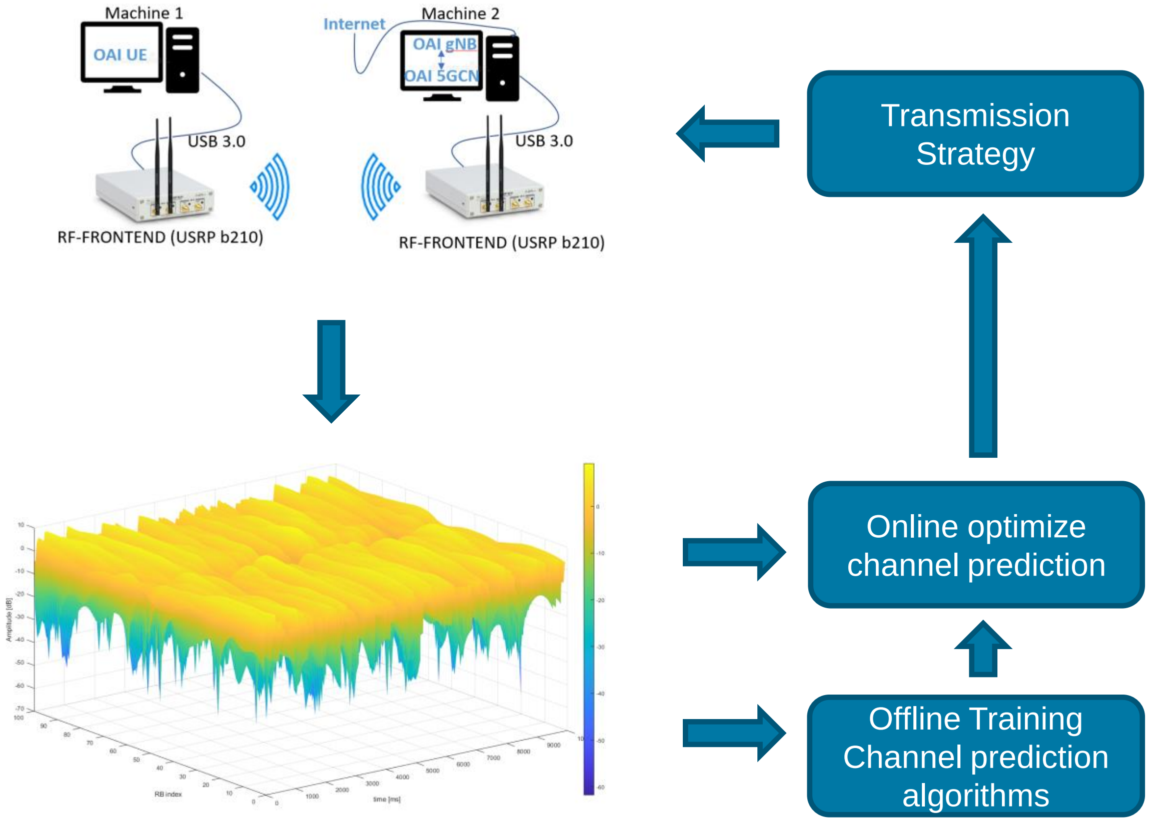
- Channel prediction
  - Frequent pilot transmission overhead due to channel phase variation
  - Using historical CSI to predict the future CSI by deep learning based time series prediction algorithms
- Beam-Tracking
  - Fully exploit the beamforming gain and provide 3D radio coverage
  - Obtain accurate CSI by serving ground Base station
  - Simultaneously track the azimuth and elevation angles of their LoS links with UAVs
- Forecast future CSI in advance with a time span that counteracts the induced delay.



RADIO ACCESS NETWORK

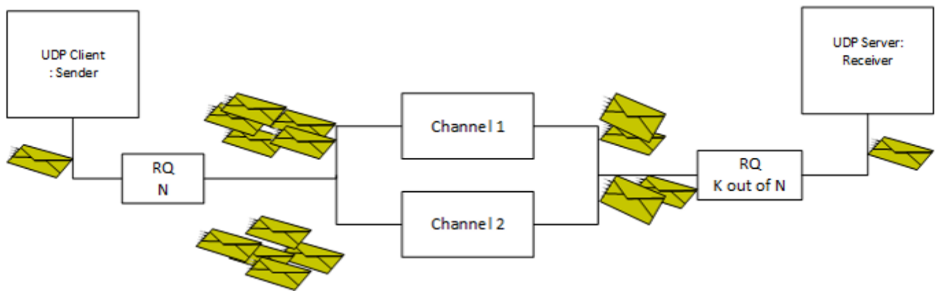
- Design appropriate channel prediction model
- Integrate channel prediction model to real platform
- Optimise transmission strategy based on predictions

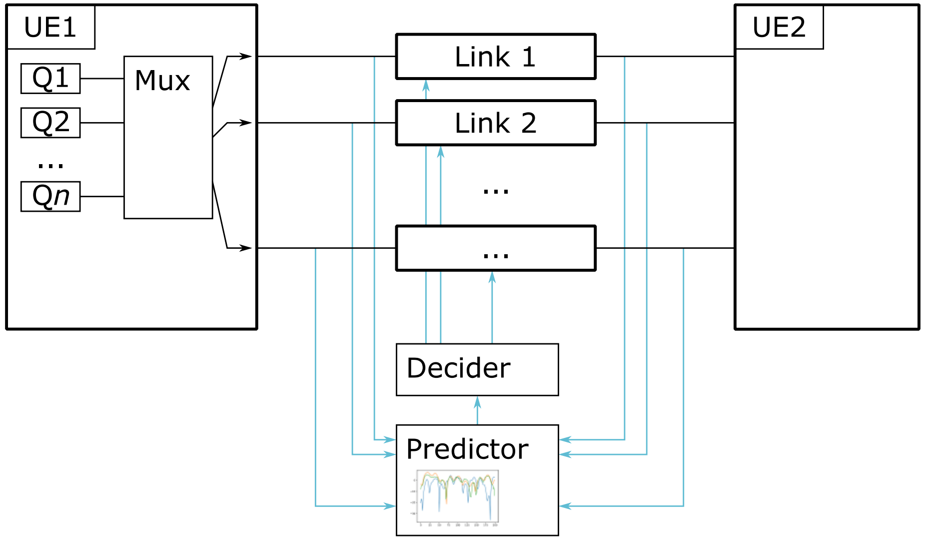
→ Decrease error rate and improve throughput.



RADIO ACCESS NETWORK

- Fountain coding (i.e. RaptorQ)
  - Erasure channel
  - Generate as many code words as necessary
  - K-out-of-N decoding
- Multi-link communication
  - Transmission of code words over different links or RANs
  - Traffic classes for requirements mapping
  - Channel prediction-based decision making





CONCLUSION AND OVERVIEW

6G SMART DRONES 6G HOLOCOM

First testing of applications

- Flugplatz Schönhagen (test area)
- Technische Hochschule Wildau (application / algorithm for flight way optimization)
- IDRF (associated partner: standardization)
- SeeReal Technologies (holograms)
- Volucap (content)
- Technische Universität Ilmenau (QoE)

Highspeed SW layer & adaptive cloud infrastructure

- Telekom (highspeed layer)
- Mobile Cloud Computing / Einstein Center / TU Berlin (mobile cloud technologies)
- Fraunhofer FOKUS (media processing / native AI for network optimization)

Testbed & Network coverage

- Deutsches Forschungszentrum für Künstliche Intelligenz GmbH (Open 6G Hub Testbed mobile)
- Logic Way GmbH (com modules)
- Telekom (network requirements & QoS of network)

THANK YOU!