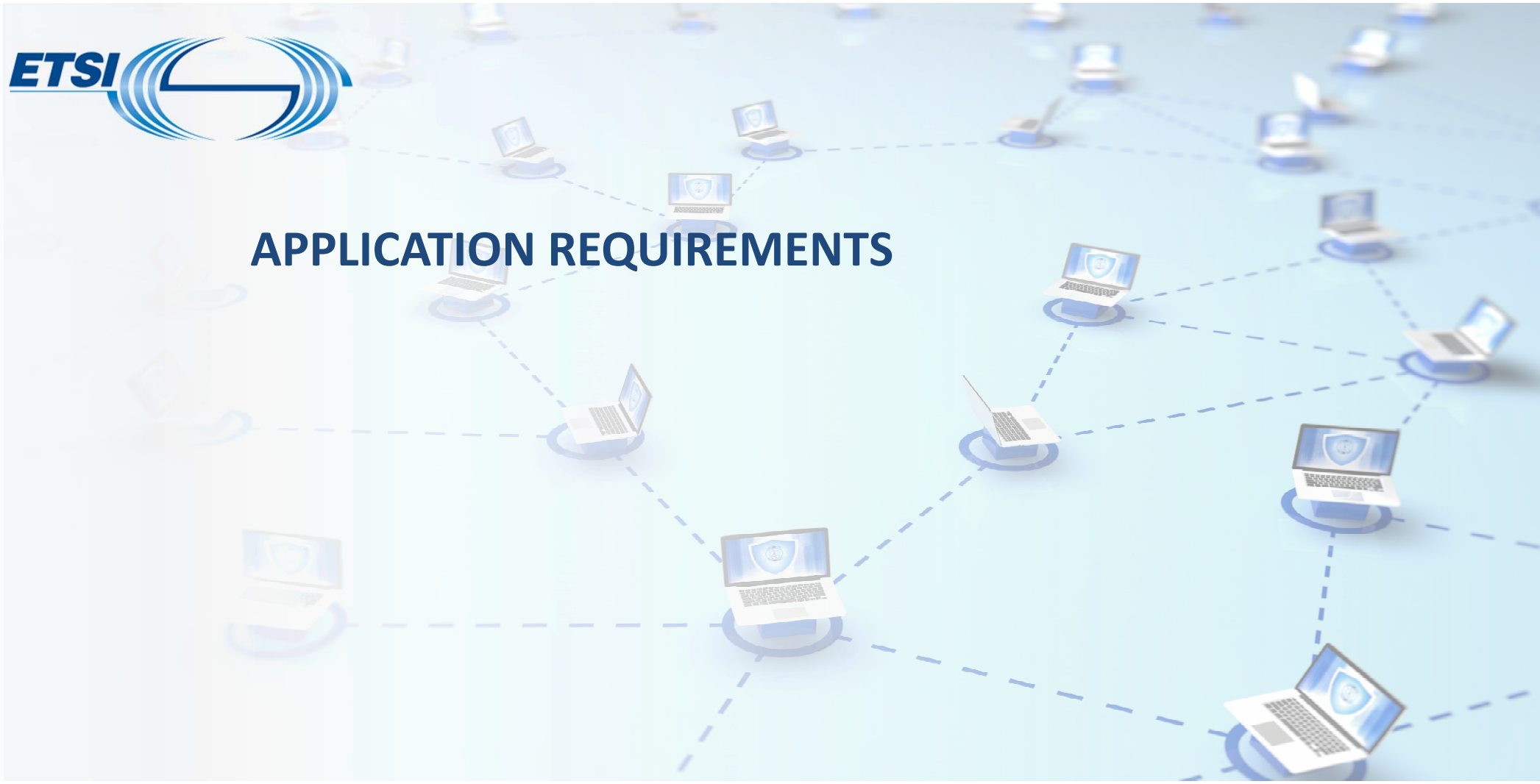
ETSI
NEW INTERNET FORUM

12 October 2018

REQUIREMENTS, CHALLENGES AND TECHNOLOGIES FOR NEXT-GENERATION COLLABORATION AND ENTERTAINMENT APPLICATIONS

Prof. Dr. Ir. Filip De Turck

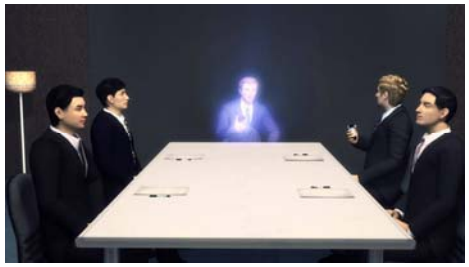
IDLab
INTERNET & DATA LAB
GHENT UNIVERSITY
imec



APPLICATION REQUIREMENTS

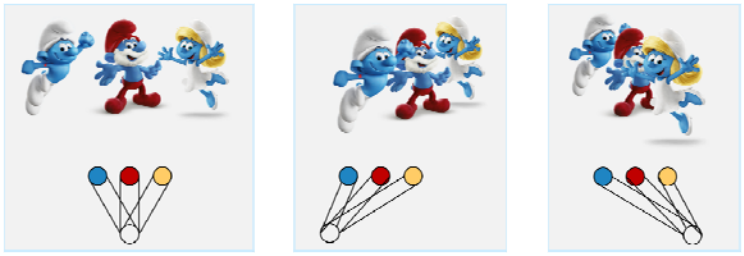
Immersive streaming applications in 2030

- Virtual reality and Holographic streaming
  - Multitude of immersive applications
    - Tele-presence, remote communication and collaboration, immersive spaces, remote troubleshooting and training, entertainment
  - Towards limitations of human sensory perception
    - Ultra-high audiovisual information bandwidth (up to Tbps)
    - Ultra-low latency for interactivity (< 1ms)



Immersive streaming applications in 2030

- Holographic-Type Communications (HTC)
  - Point clouds
    - Volumetric data, generated, streamed and rendered from any viewing angle
    - Six degrees of freedom (6DoF), beyond mere head movement in VR
    - Precise synchronization between multiple objects rendered in one scene
    - Massive amount of storage and bandwidth needed (even with compression)
    - Currently up to several Gbps of raw data (Kinect, Intel)



ARCHITECTURAL CHALLENGES

Current networking limitations

- 3GPP architectures and IP stack cannot guarantee the required throughput and latency
  - unnecessary TCP retransmissions caused by delay variations in unsynchronized radio signals
  - inefficient use of protocols due to tunneling and repetitive headers
  - protocol overhead for small packets is large

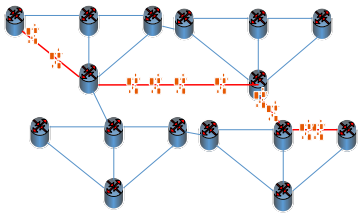
Novel networking paradigms

- High-precision networking way beyond best effort Internet
  - Network should support near-real-time transmission
  - Network should enable high-precision service guarantees
  - Multiplexing should become computational, not statistical
  - Communication protocol should transport groups of packets, not single packets
  - Communication protocol should use preferred path routing, instead of shortest path routing
  - Communication protocol should inherently meet service level objectives through in-band commands and metadata

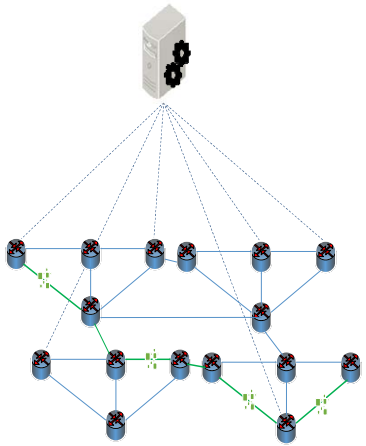
Novel architectural principles

- From best effort shortest-path routing to distributed, software-defined preferred-path routing

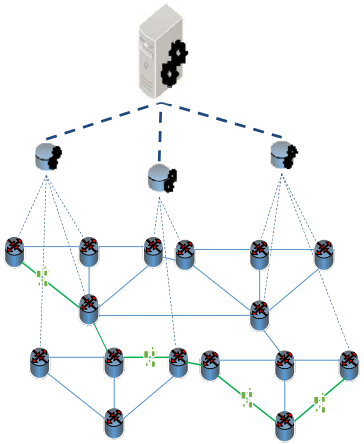
Shortest path routing



Packet switched network

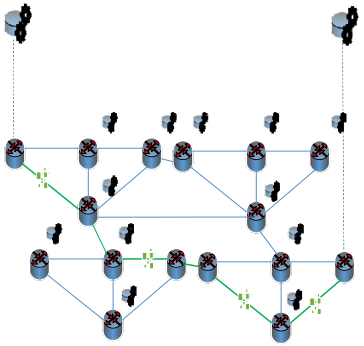


Centralized SDN



Hierarchically decentralized SDN

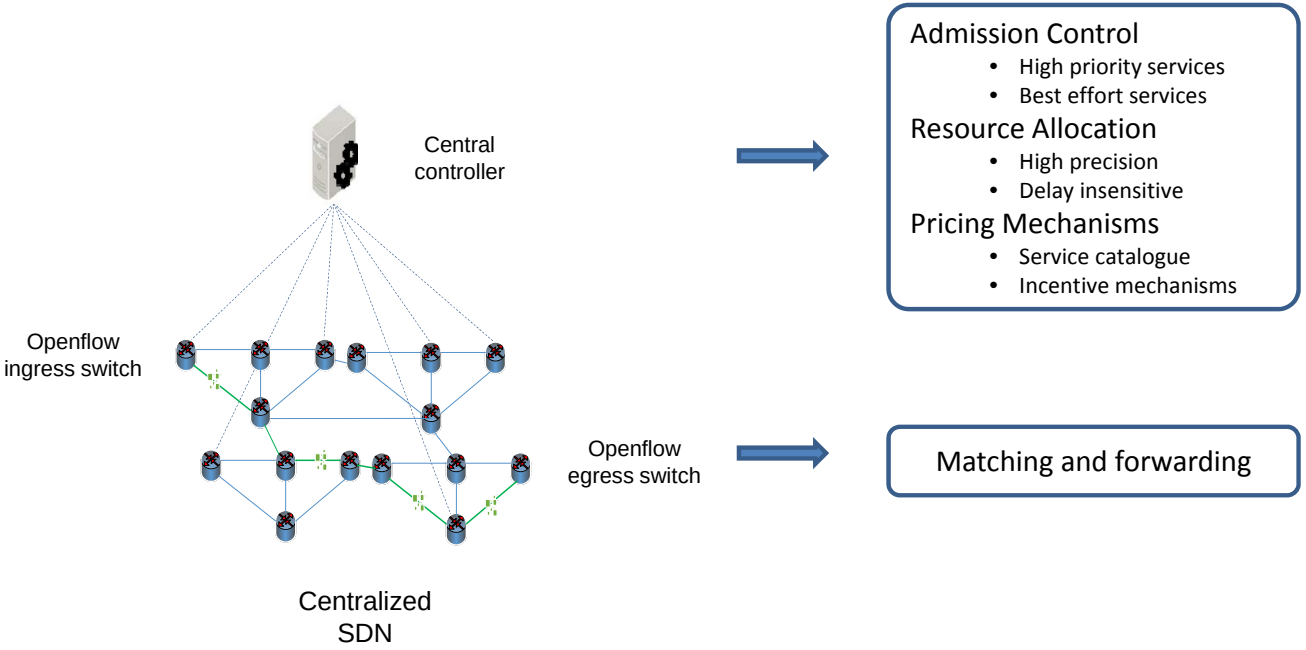
Preferred path routing



Decentralized SDN with agent-based switches

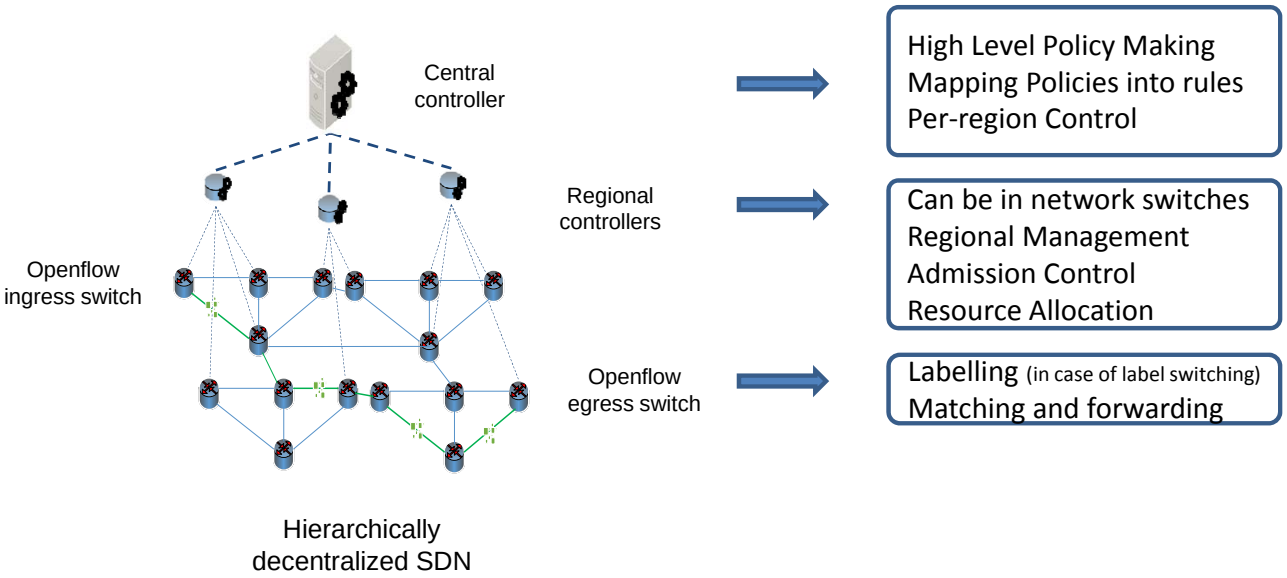
Novel architectural principles

- Centralized SDN



Novel architectural principles

- Hierarchically distributed SDN



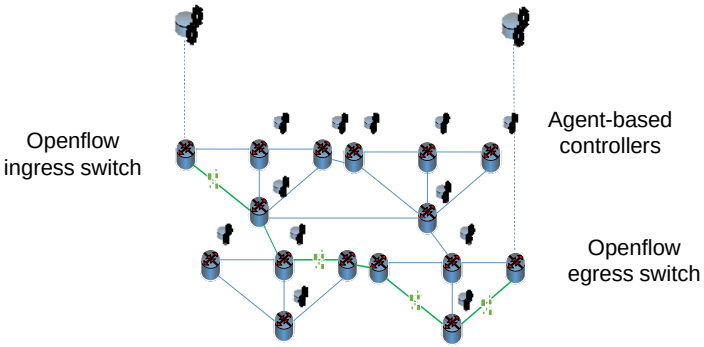
Hierarchically decentralized SDN

Example: Software Defined Label Switching (SDLS)

Nanyang Huang, Qing Li, Dong Lin, Xiaowen Li, Gengbiao Shen, Yong Jiang, "Software-Defined Label Switching: Scalable Per-flow Control in SDN"
IWQoS, 2018

Novel architectural principles

- Fully decentralized SDN



Decentralized SDN with
agent-based switches

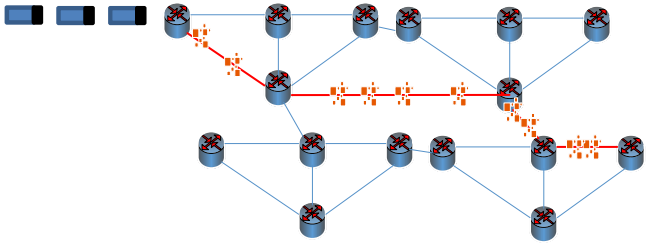
- One agent per flow
- Path computing based on information from requirement database
- Matching and forwarding
- Inter agent communication
- Label switching

Example: Distributed Active Information Model (DAIM)

Pakawat Pupatwibul, ”DAIM: New Information Model that Allows Logical Distribution of the Control Plane for Software-Defined Networking”
PhD, 2016

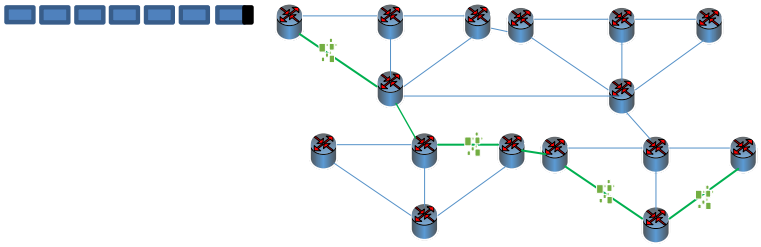
Novel architectural principles

- From packet-switched to rail-switched IP
  - Commands and metadata added to customize network behavior



Packet switched network

Reduced queuing
Reduced latency



Rail switched network

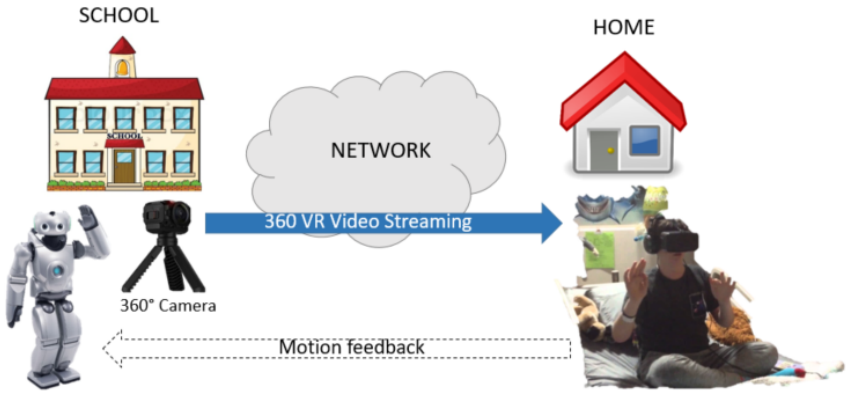
Example: Big Packet Protocol (BPP)

Li, R., Clemm, A., Chunduri, U., Dong, L., Makhijani, K., “A New Framework and Protocol for Future Networking Applications” NEAT, 2018

RESEARCH DIRECTIONS

Research directions

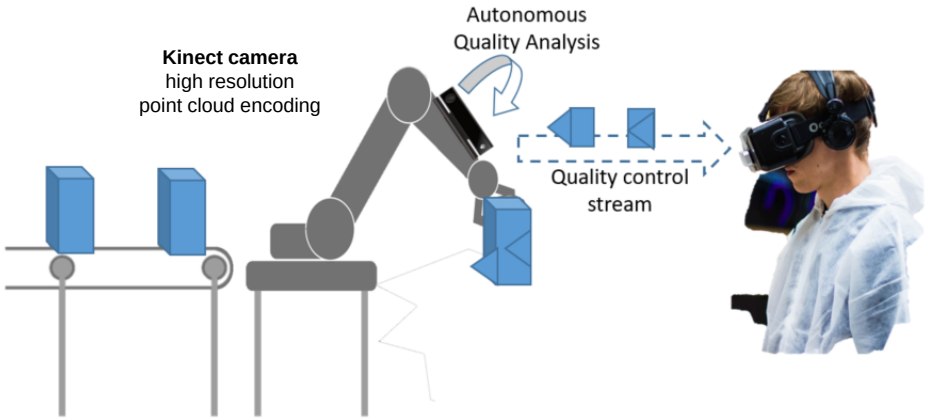
- Immersive Distance Learning and Collaboration



- Virtual Reality streaming for both interactive (WebRTC-based for low-latency) and on-demand (DASH-based for high adaptive quality) scenarios
- Robotic User Interfaces for increased sense-of-belonging and sensor-based feedback

Research directions

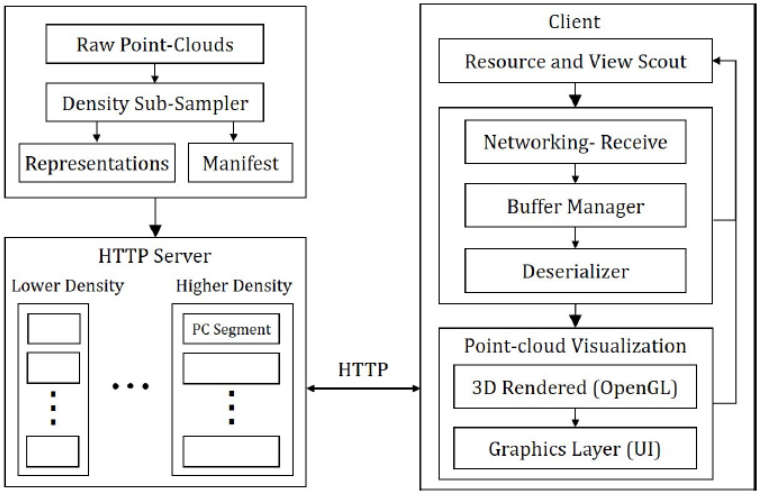
- Immersive Quality Control for Industry 4.0



- Machine learning for autonomous quality control
- Optimize high-quality streaming for control of detected anomalous objects

Research directions

- MPEG-DASH for over-the-top point-cloud streaming



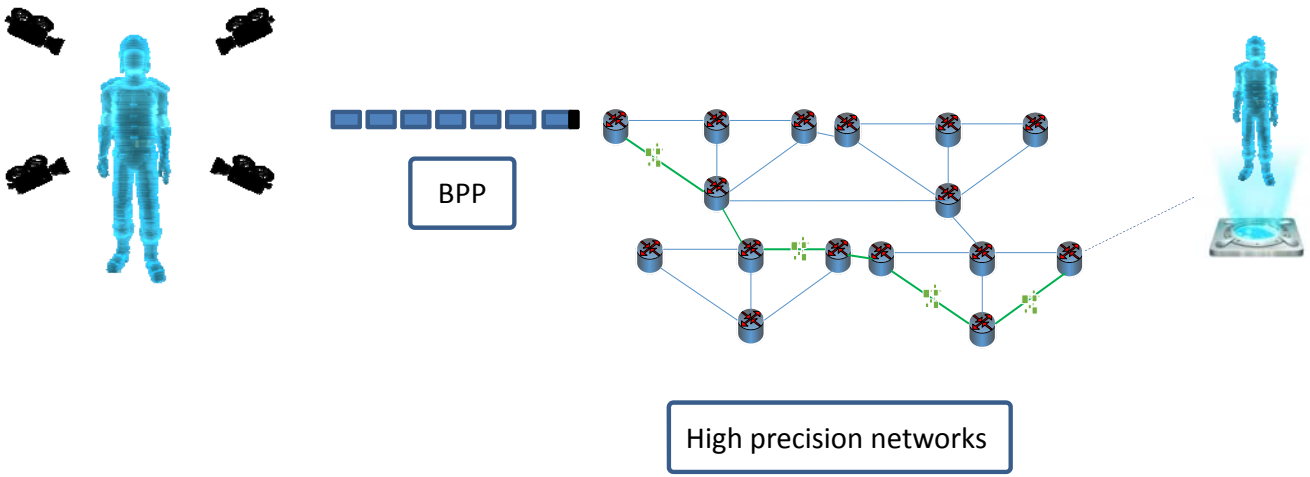
- Improve rendering performance
- Optimize adaptive bandwidth usage
- Tackle processing requirements
- Exploit HTTP/2 Push mechanisms
- Develop rate adaptation algorithms

Example: DASH-PC

M. Hosseini, C. Timmerer,
"Dynamic Adaptive Point Cloud Streaming"
MMSys, 2018

Research directions

- Distributed networking with rail-switched packets for holographic streaming



- Decentralized control plane
- Resource allocation based on biology-inspired algorithms (e.g. Bat algorithm)
- Rail switching
- Incentive-based mechanisms
- Preferred path routing
- Multi-level services objectives

Example: Bat algorithm

R. Lin and Z. YeLi, “A bat algorithm for SDN network scheduling” Journal on Wireless Communications and Networking, 2018

ETSI
NEW INTERNET FORUM

12 October 2018

REQUIREMENTS, CHALLENGES AND TECHNOLOGIES FOR NEXT-GENERATION COLLABORATION AND ENTERTAINMENT APPLICATIONS

Prof. Dr. Ir. Filip De Turck

IDLab
INTERNET & DATA LAB
GHENT UNIVERSITY
imec