NTNU | Norwegian University of Science and Technology

Towards Smart Public Interconnected Networks and Services

Approaching the Stumbling Blocks

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KuVS Fachgespräch “Network Softwarization”
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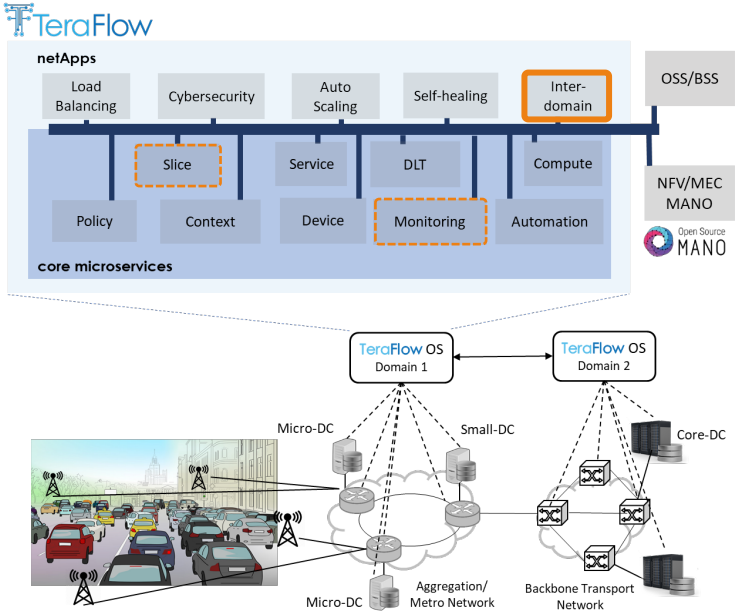
Context: TeraFlow H2020

- Research areas
  - Secure autonomic **traffic management**
  - Smart **connectivity**
  - Business **agility**
  - **Automation in B5G** networks
- Contribution: **open-source cloud-native** SDN controller ›**teraflow-h2020.eu/teraflow-os**
- Use cases
  - Autonomous networks beyond 5G
  - Automotive
  - Cybersecurity

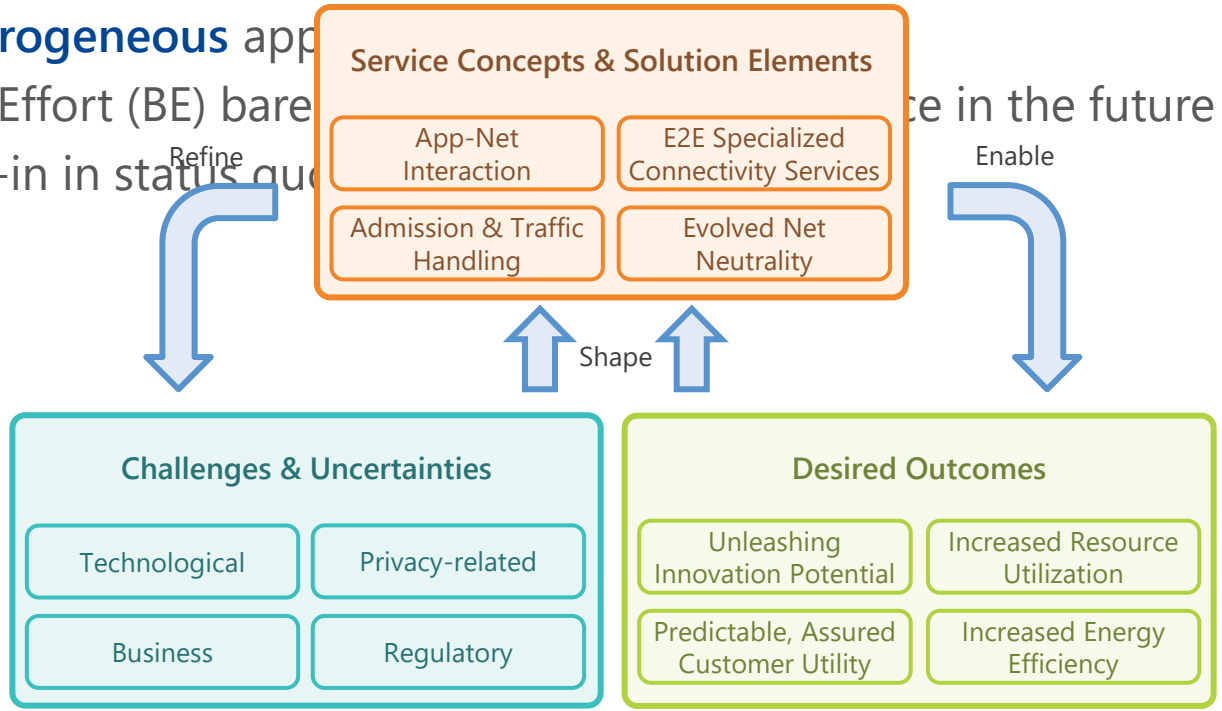


Focus @ NTNU

- **Inter-domain** connectivity
- **Smart public interconnected** networks and services (PINS)

Towards Smart PINS

- Lack of availability & need for **end-to-end connectivity w/ QoS**
  - **Heterogeneous** app
  - Best Effort (BE) bare ce in the future
  - Lock-in in status qu



Challenges & Uncertainties

Technological Challenges

- Expressing needs & offerings
- QoS-to-QoE mapping

Business-related Uncertainties

- Lock-in @ overprovisioning cycle
- Fear of disrupting business models

Privacy Challenges

- Unclear payoff
- Encryption vs. app-awareness

Regulatory Uncertainties

- Differentiation vs. net neutrality
- Evolved net neutrality

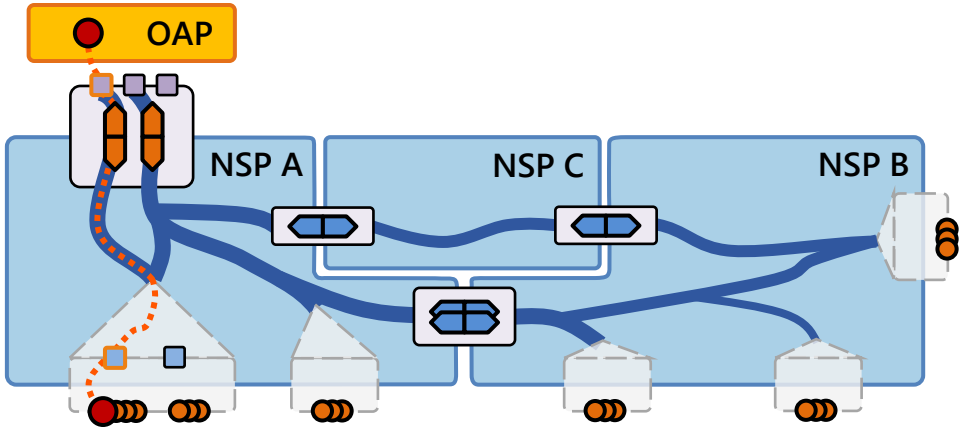
Service Concepts and Enablers

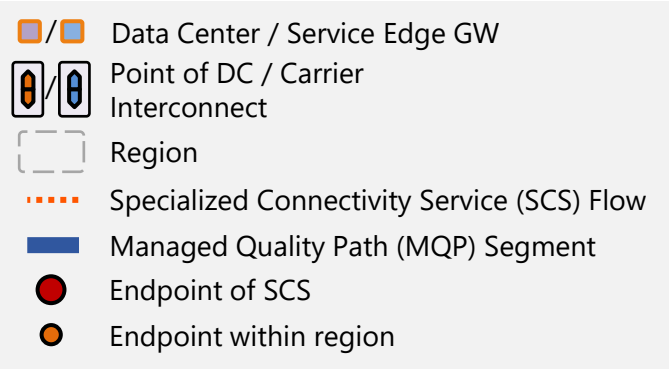
- Traffic modes for differentiation
- Traffic aggregates for scalability
- Solution elements & challenges

Traffic Differentiation

- **"Traffic modes"** – currently just BE on the public Internet
- Idea: reflect app heterogeneity with **multiple traffic modes**
  - Enable **relative and absolute** differentiation
  - Limit control plane complexity
- ➔ **Multi-level best effort**
  - Background (BG) ~ OS-initiated download of updates
  - Basic Quality (BQ) ~ User-initiated file download ~ Current BE Internet
  - Improved Quality (IQ) ~ User-initiated VoD
  - Assured Quality (AQ) ~ Critical service

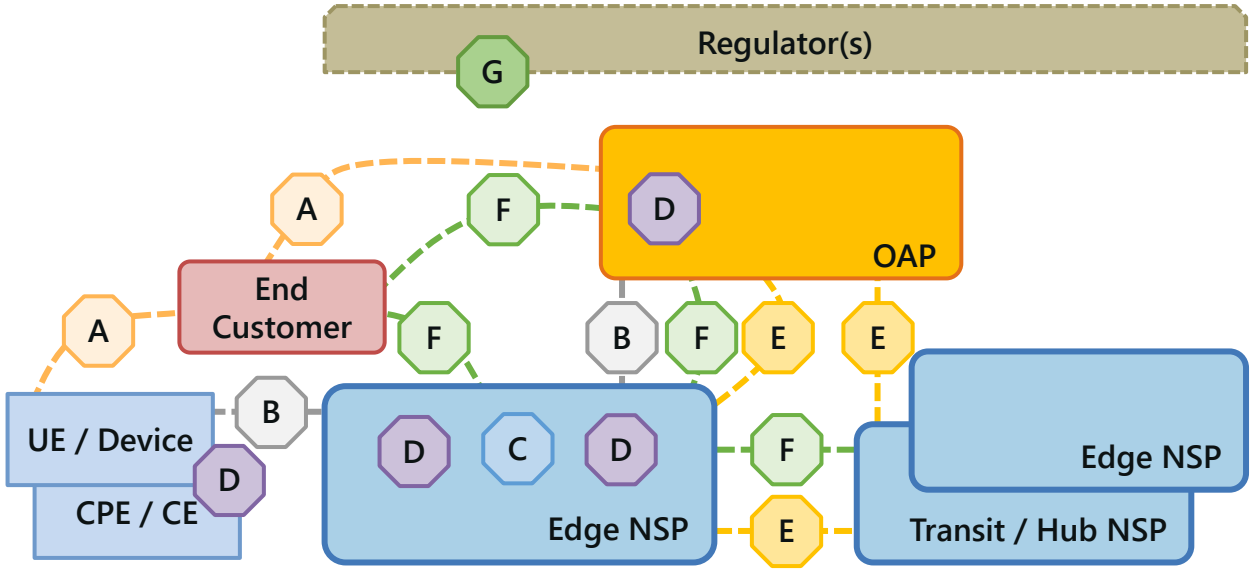
Connectivity Handling





- On-demand end-to-end per-flow connection establishment infeasible
- → **Multiple** granularity levels of **traffic aggregates**
  - Coarse: high-capacity, long-lived, pre-established ***Managed Quality Paths***
  - Fine: dynamic, on-demand ***Specialized Connectivity Flows***

Solution Elements



- A User Interface / Experience (UI / UX)
- B Application-Network Interaction
- C Lightweight Admission Handling
- D Quality of Service (QoS)
- E Point-of-Interconnect-to-Region (PoI2R)
- F Business Model Elements
- G Evolved Net Neutrality

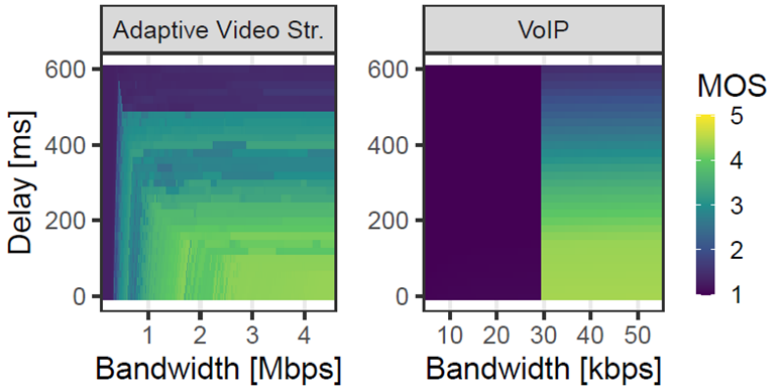
Summary of Concepts

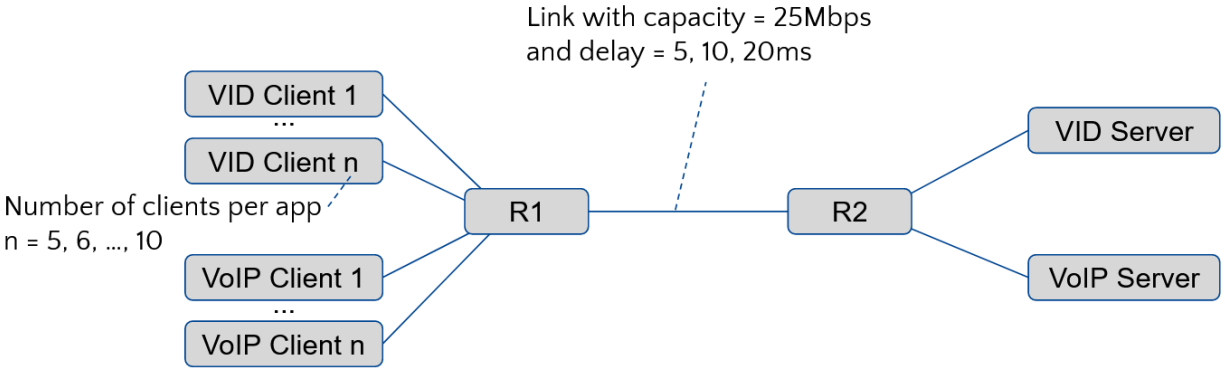
- Traffic modes for **differentiation** beyond traditional best effort
  - ➔ **Multi-level best effort**
- Traffic aggregates for **scalable** connectivity handling
  - ➔ **Managed quality paths, specialized connectivity services**
- **Solution elements** to address challenges
  - Technological
  - Business-related
  - Regulatory

➔ Next: simulations to investigate potential benefits

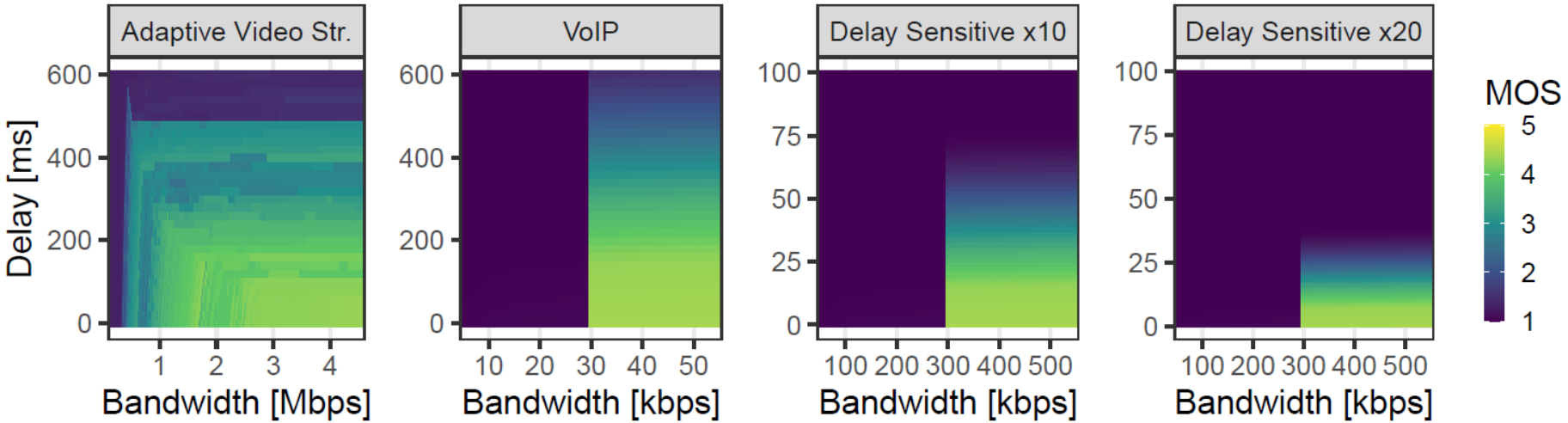
Simulations

- OMNeT-based DES
- HTB for resource allocation
- QoS-to-QoE heatmaps ➔ heterogeneity
- Network setup





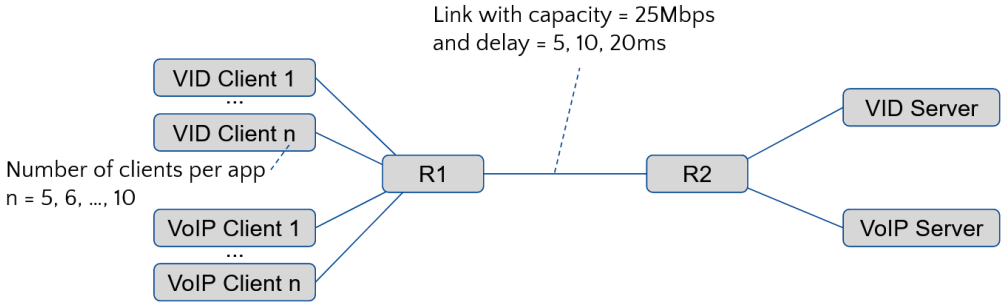
Extrapolating Application Behavior



- Mimic emerging, e.g., haptic, apps by **adjusting VoIP heatmaps** [1]
  - **Bandwidth** requirements & usage **x10** by adjusting packet IATs
  - **Delay** requirements **x10, x20** by feeding the e-model inflated values

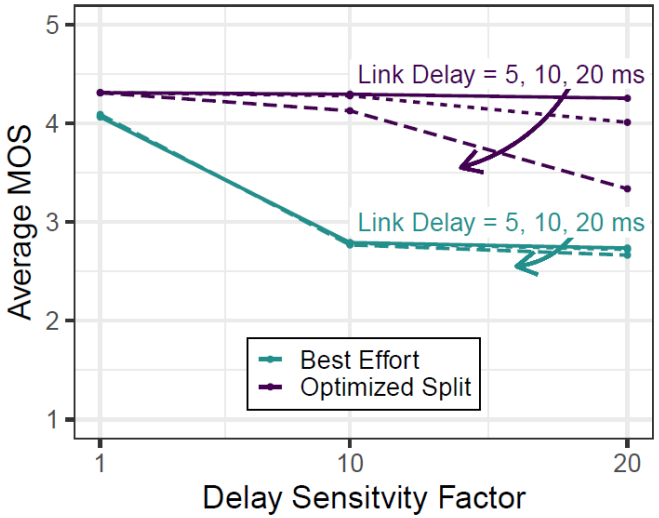
[1] Q. Zhang, J. Liu, G. Zhao, "Towards 5G Enabled Tactile Robotic Telesurgery," https://arxiv.org/abs/1803.03586

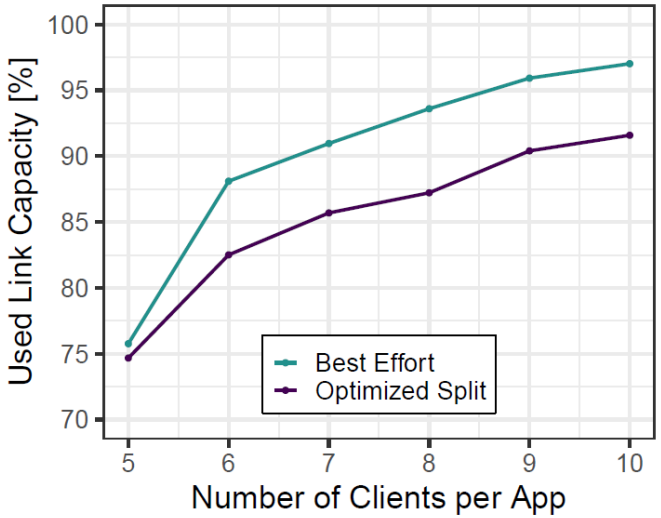
Simulation Setup



- **2-app scenarios**, mixing VID with {VoIP, DSx10, DSx20}
- Resource allocation schemes
  1. **BE**: everything on one link, no QoS-flows
  2. **Optimized split**
     - No QoS-flows, just per-app slices w/ strict isolation
     - For each load / app mix setting, try capacity splits (5%, 95%), (10%, 90%), …, (95%, 5%) for the two applications
     - Pick the one that maximizes avg. QoE

Evaluation Results





- **BE works for current-gen apps**, but breaks with increased delay sensitivity
- **Optimized split can maintain good QoE** unless prohibitive link delay
- Bonus: can **save link capacity**, i.e., admit more users / save energy / …

Directions for Future Work

- **Testbed-based validation** of multi-app scenarios
- More **realistic** delay-sensitive applications
- Formalization / modeling of **traffic aggregation** mechanisms