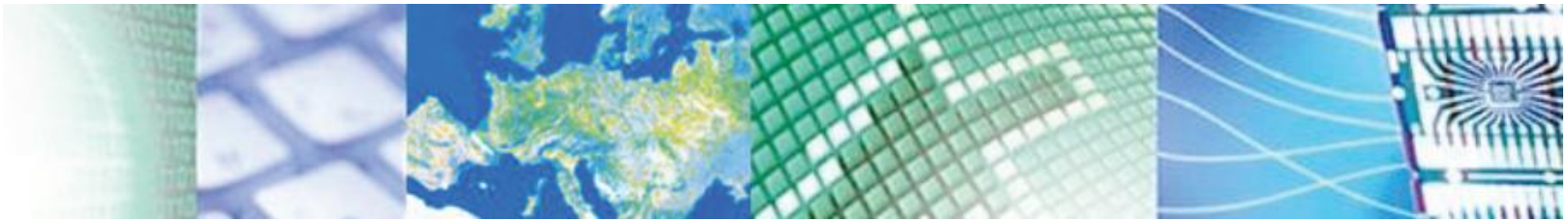


CHIST-ERA Projects Seminar 2023
Smart Distribution of Computing in Dynamic Networks (SDCDN)

April 05, 2023

Programme co-funded by the
EUROPEAN UNION

Introduction: Projects of SDCDN

❖**CONNECT: COmmunicatioN-aware dyNamic Edge CompuTing**

❖**DiPET: Distributed Stream Processing on Fog and Edge Systems via Transprecise computing**

❖**DRUID-NET: eDge computing ResoUrce allocatIon for Dynamic NETworks**

❖**LeadingEdge: Holistic and Foundational Resource Allocation framework for optimized and impactful edge computing services**

❖**SCORING: Smart Collaborative cOmputing, caching and netwoRking**

Major Achievements and Outputs

CONNECT

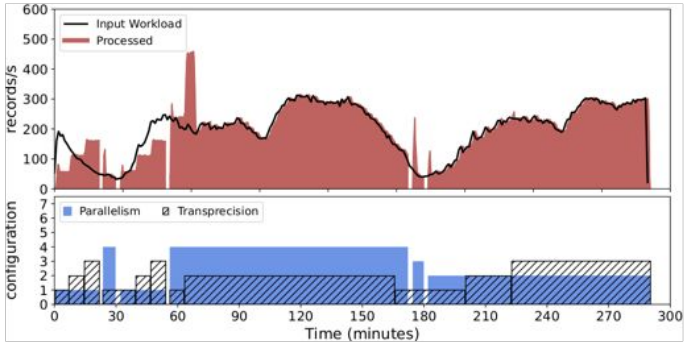
- Distributed learning at the wireless edge
  - ✔ Person re-identification over noisy channels
  - ✔ Neural networks in the air
  - ✔ Fully distributed learning: GADDM, Q-GADMM, A-FADMM
  - ✔ Collaborative relaying for FL
  - ✔ FL for hybrid beamforming, channel estimation
  - ✔ Hybrid federated and centralized learning
- Hierarchical heterogeneous networking architecture
  - ✔ Wireless channel modeling and estimation: IEEE 802.11p, C-V2X, VLC
  - ✔ Machine learning based link quality estimation and jamming detection based on real-world data
  - ✔ Implementation of FL algorithms on software platform: SUMO+ns3+Python
  - ✔ Validation of FL algorithms on moving vehicles for pedestrian detection

Major Achievements and Outputs

DiPET

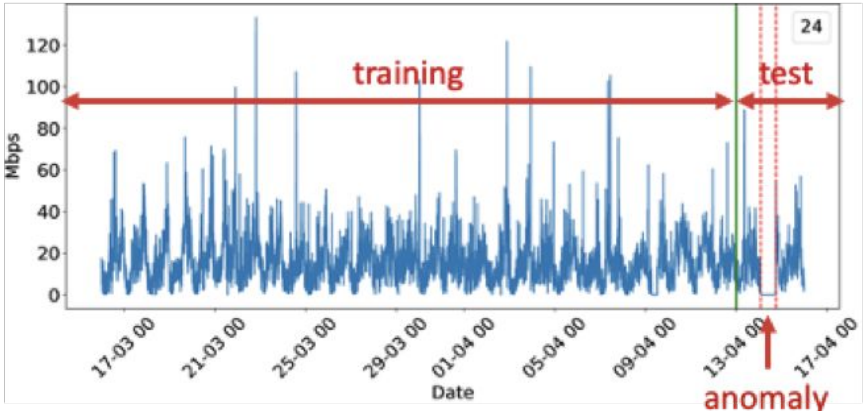
TransScale: Combined-Approach elasticity auto-scaler

- Horizontal Scaling + Transprecision Control
- QoS-based re-configuration decisions



Anomaly detection in community network

Using unsupervised machine learning

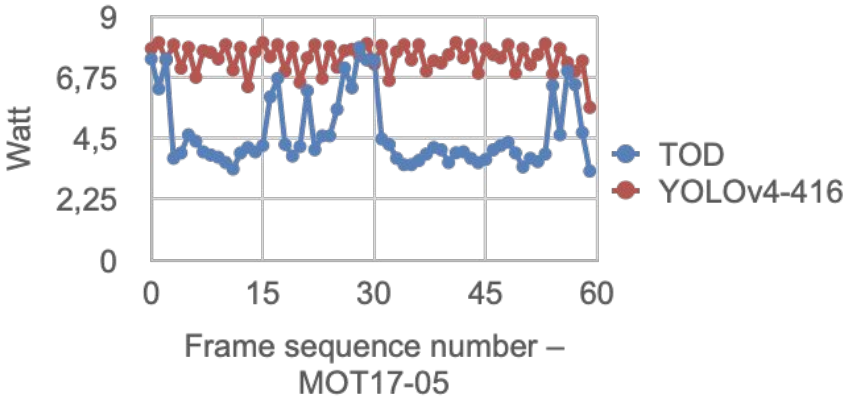


Traffic feature of a node showing the training and testing sets (left and right of the Green line) and the failure interval (red lines).

Open Dataset DOI: 10.5281/zenodo.6169917

Transprecise object detection:

- Trade-off between network complexity, object size, speed of movement, and frame rate
- Runtime dynamic model adaptation to reduce energy consumption

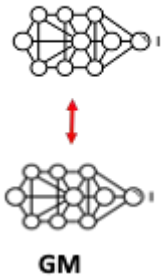


Major Achievements and Outputs

LeadingEdge

❖ Learning amidst uncertainties

→ Centralized and decentralized control subject to resource constraints in edge computing



❖ Fundamental performance limits

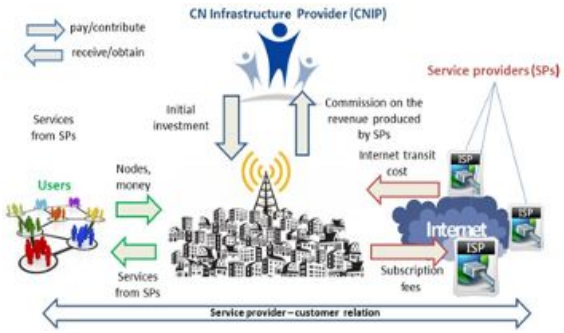
→ Low latency for 5G Communication, Age of Information optimal IoT

❖ AI-based system-level service orchestrator

→ Trirematics-Operator

❖ Federated Learning

→ Personalization



→ Addressing non-i.i. Data

❖ Economics of novel architectures

→ Multi-operator network slicing

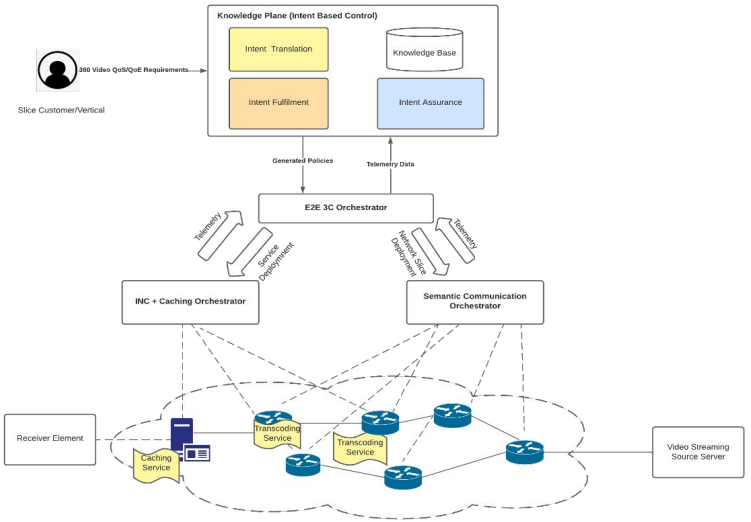
→ Interaction of multiple service providers over a Community network infrastructure

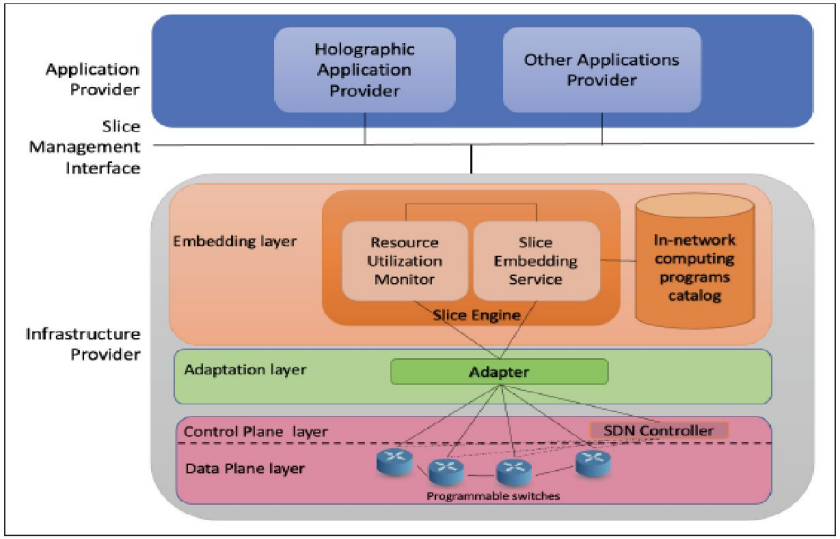
New Community network based services

→ Accountability of distributed transactions of IoT devices via Ledger technologies

Major Achievements and Outputs

- A proposed SCORING Architecture (and a set of associated AI-based mechanisms) for the INC-Edge-Cloud Continuum in NGNI
  - An Intent based 3C-oriented Control perspective, following latest standards (**TmForum, IETF**).
  - Leveraging In-Network Computing Capabilities at the Data Plan (INC-Extended P4 Switches) for End User Services offering
  - An AI-toolset as a 3C (Communication, Caching, Computing) meta-orchestrator for autonomous compute-centric networking
  - Shapley Based Fair and Cost Efficient Dynamic Joint Load Balancing and Pricing
- Proof-of-concept implementations of SCORING-based enablement of Holographic-Types Communications and 360° video services based on INC-Edge-Cloud Continuum and Intent-based 3C Slicing in NGNI
- Multiple joint submissions to journals (2 surveys), magazines (IBN 3C Slicing) and invited conference papers (vision/position paper)

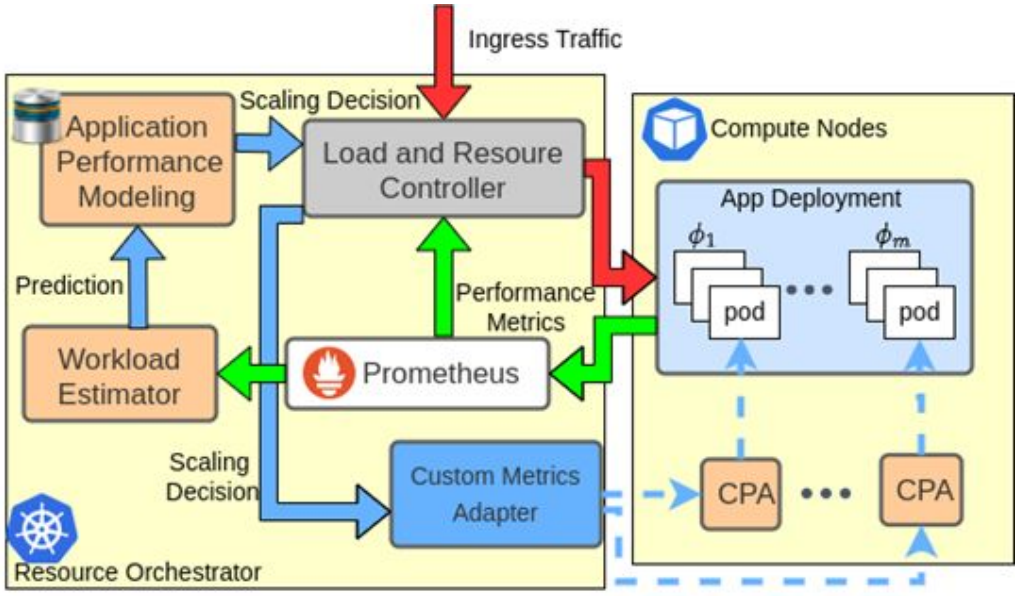




Major Achievements and Outputs

DRUID-NET:

- ❖Workload Estimation
  - ➢ Device Profiling
  - ➢Application Profiling
  - ➢Mobility Profiling
- ❖Performance Modeling
  - ➢ML-based Models (Desired QoS metrics → virtual resources
- ❖Resource Allocation
  - ➢Co-design with CPS control algorithms
  - ➢Resource Scheduling
  - ➢Task Offloading
  - ➢Application Migration



Upcoming Challenges and Needs

1. Energy-efficient AI
2. Distributed Computing/AI under stringent resource limitations
3. Federated multi-cloud orchestration for the cloud continuum (all levels from cloud up to device)
4. Intent- and goal-based management/orchestration across multiple resource dimensions (cache capacity, computation capacity, bandwidth, energy, access points, datasets)
5. From Information Centricity to In-Network Programmability
6. Multi-stakeholder interaction and resource/sharing models
7. Trustworthiness in AI at the edge

Possible Roadmap

1. Design AI algorithms at the edge with minimum environmental footprint → exploit renewable resources (C1)
2. Approximate Computing, Transprecise computing → models with adaptable complexity to match compute availability (C2)
3. Advanced APIs for cloud orchestrators on top of K8S and OpenStack (C3)
4. Multi-objective optimization and Reinforcement Learning → ultra-high energy efficiency, data analytics accuracy, throughput, cache hit ratio, computational rate, reliability, low delay (C4)
5. ML/FL-based meta-orchestration for autonomous, semantic-driven compute-centric networking (C4)
6. Definition/translation of application goals to network requirements and monitoring of their achievability using semantic communication principles (C4)
7. Extension of SDN functionalities to address application function execution in network devices (C5)
8. Advanced economics/cost sharing models for multi-resource, multi-stakeholder environments (C6)
9. Privacy- , reliability, explainability and energy awareness in AI @the edge (C7)

Role of the CHIST-ERA Support

- **CHIST-ERA: a good instrument for collaborative cross-EU research with a focus on blue sky research, with reduced administrative overhead of many other EU funding schemes**

- **Harmonize as much as possible the administrative rules and procedures between CHIST-ERA and national agencies**

- **CHIST-ERA platform provides good support to project participants and project Coordinators**

Complementarity with Horizon Europe

- **Digital, Industry and Space**
- **HORIZON-CL4-2022- DATA-01-02:** Cognitive Cloud: AI-enabled computing continuum from Cloud to Edge (RIA)
- **HORIZON-CL4-2022- DATA-01-03:** Programming tools for decentralised intelligence and swarms (RIA)
- **HORIZON-CL4-2023-HUMAN-01-01:** Efficient trustworthy AI - making the best of data (AI, Data and Robotics Partnership) (RIA)
- **HORIZON-CL4-2023-DATA-01-04:** Cognitive Computing Continuum: Intelligence and automation for more efficient data processing (AI, data and robotics partnership) (RIA)
- **HORIZON-CL4-2024-DIGITAL-EMERGING-01-03:** Novel paradigms and approaches, towards AI-powered robots– step change in functionality (AI, data and robotics partnership) (RIA)
- **6G Smart Networks and Services** calls (2023-2024)

Responsible Research & Innovation

- ❖DRUID-NET: Gender balance - 30% female researchers.
  - ➢Open-source repositories for sharing code and data
  - ➢Train new PhD and undergraduate students
- ❖LeadingEdge: Gender balance - 30% female researchers
  - ➢Input to M.Sc and undergraduate courses
  - ➢Training of junior researchers in cutting-edge topics (e.g. implementation of AI algorithms on real devices)
- ❖SCORING: Gender balance - 50% female researchers.
  - ➢Open-source repository for sharing code and data
  - ➢Train new PhDs as well as graduate and undergraduate students.
- ❖DiPET: Gender balance - one female in consortium
- ❖CONNECT: Gender balance - one female in consortium (coordinator)
  - ➢Open-source repository for sharing code and data

Open Science

❖**Reproducible science:**

➢Pros: datasets and codes are easily reproduced, and there is willingness to share them among projects (github repositories with code and data)

➢Cons: difficulty to reproduce identical results because of hardware dependencies (no joint infrastructure or hardware settings among projects and, more globally, research initiatives around SDCDN topics)

❖**Open Access:**

➢Pros: Detailed DMP guidelines by CHIST-ERA and the provision of DMP tools like Zenodo and Argos.

Technology Transfer

❖Multiple projects started discussions (since the 2021 Projects Seminar) with industry for new projects and/or technology transfer:

➢Nokia Bell Labs
➢Ericsson
➢HUAWEI
➢OVHCloud
➢EURECOM spinoff, BubbleRAN
➢Moy Park
➢Cisco
➢Rakuten
+ other SMEs

Questions

Questions ?