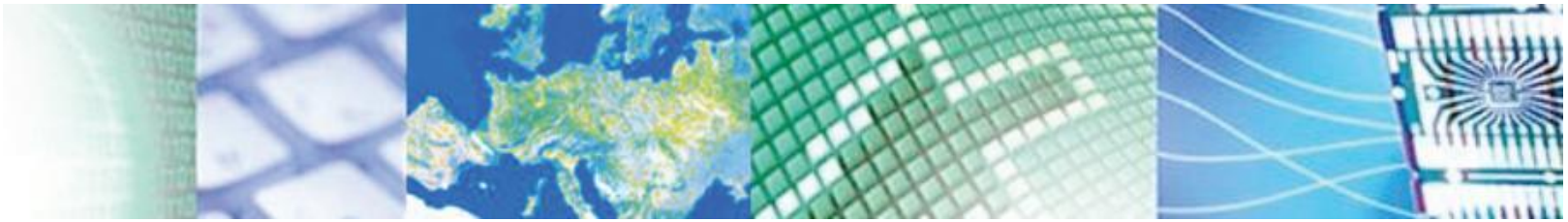

CHIST-ERA Projects Seminar 2022
Smart Distribution of Computing in Dynamic Networks (SDCDN)

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March 29, 2022

Programme co-funded by the
EUROPEAN UNION

Introduction: Projects of the Topic

- **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 paradIgm for next Generation communication infrastructures**

Major Achievements and Outputs

CONNECT

❖ Distributed learning at the wireless edge

- ✓ Person re-identification over noisy channels
- ✓ Neural networks in the air
- ✓ Remote controlled Markov Decision Process
- ✓ Fully distributed learning: GADDM, Q-GADMM, A-FADMM
- ✓ FL for hybrid beamforming, channel estimation

❖ Hierarchical heterogeneous networking architecture

- ✓ Communication technologies: IEEE 802.11p, C-V2X, mmWave, VLC
- ✓ Machine learning based link quality estimation and jamming detection based on real-world data
- ✓ Reinforcement learning based network selection in heterogeneous VANET

Major Achievements and Outputs

DiPET

Modelling of elasticity in streaming application

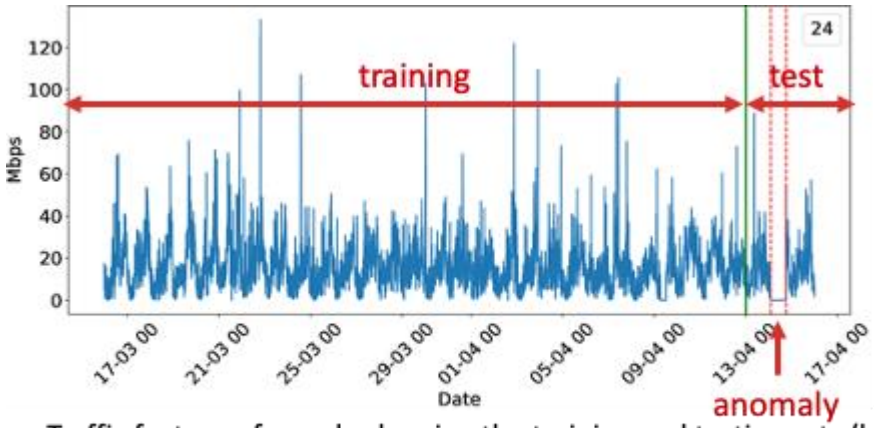
- <2% modelling error

Event Detection Engine

- Online monitoring tool
- https://github.com/DIPET-UVT/EDE-Dipet

Anomaly detection in community network

Using unsupervised machine learning

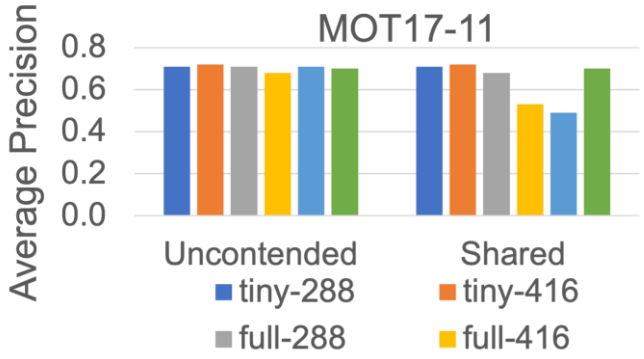


Traffic feature of a node showing the training and testing sets (left and right of the Green line) and the failure interval (red lines).

Open Dataset DOI: 10.5281/zenodo.6169917

Transprecise object detection:

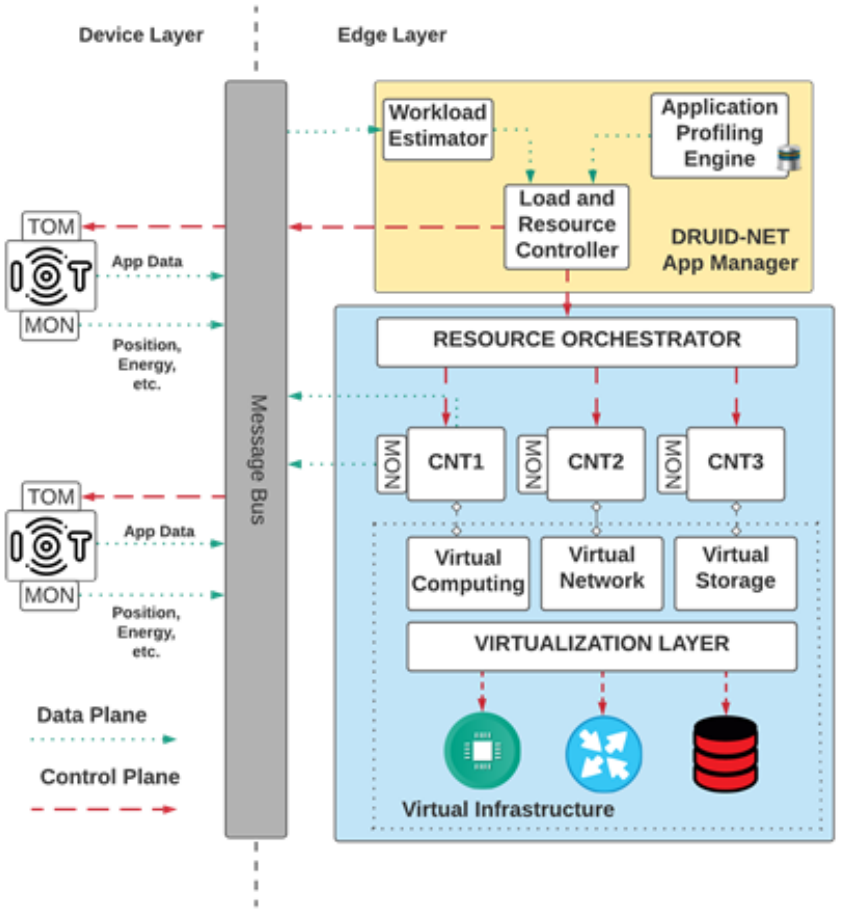
- Runtime decision-making to select 1-of-N YOLOv4 neural networks, dependent on video content
- Trade-off between network complexity, object size, speed of movement, and frame rate



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



Major achievements and Outputs

- Learning amidst uncertainties

→ Online Convex Optimization for user association and for Edge Computing

- Fundamental performance limits

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

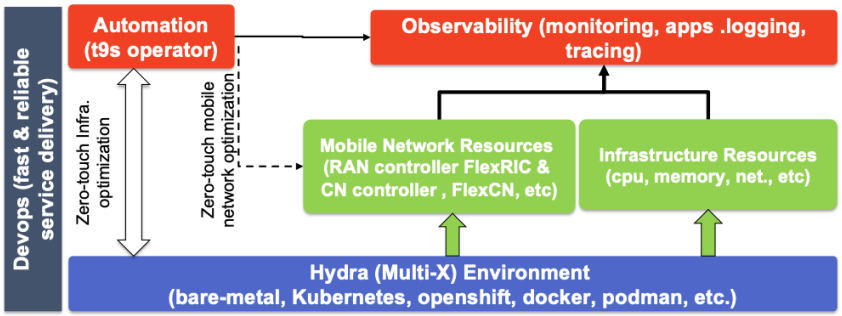
- Novel use of cache resources for Augmented Reality
- AI-based system-level service orchestrator

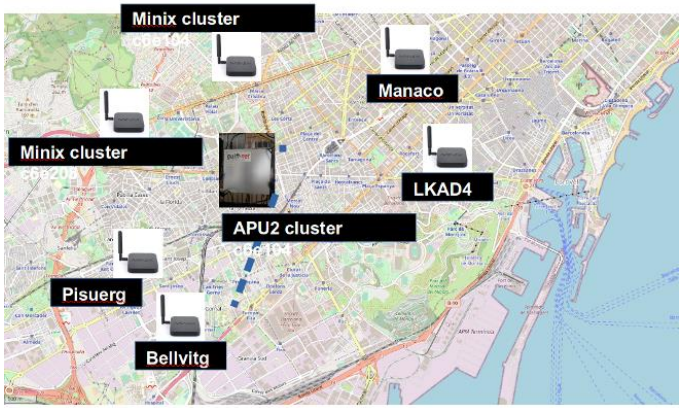
→ Trirematics-Operator (management and orchestration tool to support different deployment scenarios

- Federated Learning experimentation
- New Community network based services

→ eReuse: Distributed Ledger Technology platform for accountability of device Reuse

Trirematics (t9s) Architecture

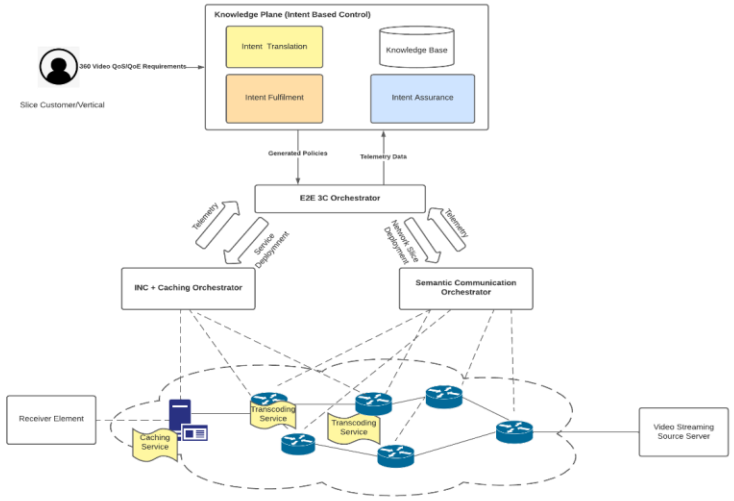


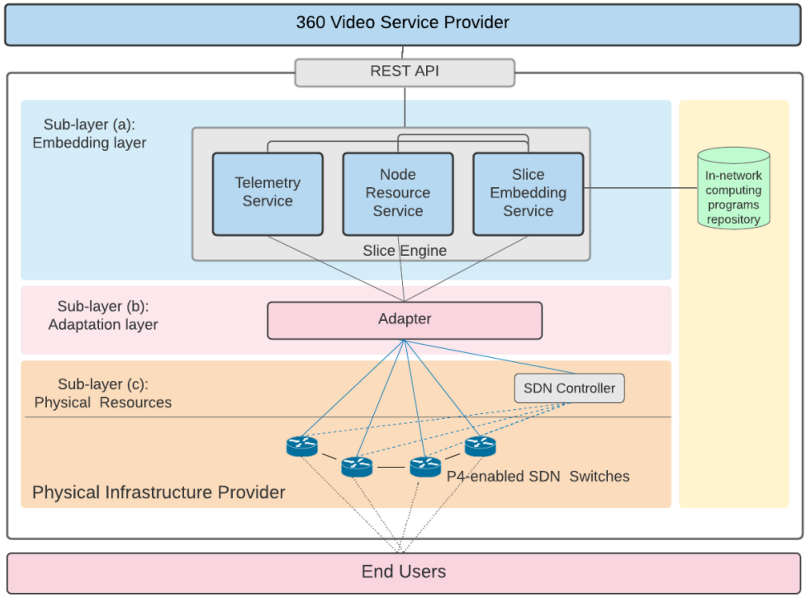


Major Achievements and Outputs

SCORING

- Towards a Tightly-Coupled Computing, Storage and Networking Architecture for NGNI
  - ✓ 8 use cases: Use case definition, requirement analysis and KPI identification
- A global SCORING Architecture (and a set of associated AI-based mechanisms)
  - ✓ Knowledge Plan: An Intent based 3C-oriented Control perspective with goal-oriented communication.
  - ✓ A 3C (Communication, Caching, Computing) meta-orchestrator for autonomous semantic-based compute-centric networking
  - ✓ In-Network Computing Capabilities at the Data Plan (INC-Extended P4 Switches)
- Proof-of-concept implementation of In-Network Computing based 360° video infrastructure (INC extension of P4 Switches)
- Two joint recent submissions: one survey paper (journal) and one vision paper (invited conference paper)





Upcoming Challenges and Needs

1. Systematic approach across multiple resource dimensions (cache capacity, computation capacity, bandwidth, energy, access points, available data)
2. Co-design of resource allocation mechanisms with control and optimization algorithms of future network applications
3. Real-time Dynamic Resource Scaling Extensions for popular cloud/IoT orchestration software.
4. Economics/cost models of edge-based cloudlets
5. Understanding the value of edge computing: latency, privacy, convenience, …?
6. From Information Centric Networking to Named Function Networking using P4 language : a multi-stakeholder perspective.
7. Intent-based and Goal-oriented joint placement, monitoring and orchestration of 3C (Communications, Caching, Computing) resources.
8. AI at the edge on resource-limited devices

Possible Roadmap

1. Multi-objective optimization (ultra-high energy efficiency, high traffic throughput, high cache hit ratio, high computational rate, delay, reliability, high data analytics efficiency/accuracy,...). (C1)
2. Creating dynamic workload estimators, performance models and resource allocation strategies (C2)
3. Developing plugins for cloud orchestrators such as K8S and OpenStack (C3)
4. Network-economic models to support service offering in multi-stakeholder settings of cloud continuum. (C4)
5. Dealing with uncertainties, information incompleteness and common pool resources (C5)
6. Extension of SDN functionalities to address application function execution in network nodes (P4 switches) in a multi-stakeholders environment. (C6)
7. ML/FL-based meta-orchestration for autonomous semantic-based compute-centric networking (i.e. taking into account tightly coupled 3C - Communication, Caching, Computing - settings). (C7)
8. Scenario-specific proof-of-concept implementation of the architecture for tightly coupled 3C for intent-based networking model. (C7)
9. Defining and translating application goals to network requirements as well as monitoring the achievement of these requirements using semantic communications principles (to ensure the compatibility with application-expressed goals). (C7)
10. Novel modes of use of edge resources, coping with unknown dynamics (C8)

Role of the CHIST-ERA Support

- **CHIST-ERA is very welcome; very good instrument for collaborative cross-EU research with a focus on blue skies research and without the administrative overhead of many other EU funding schemes**

- **Support by national agencies is patchy and unpredictable until shortly before call deadlines; would help to build consortia if participation was more uniform or known longer in advance**

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

Responsible Research & Innovation

- DiPET: Gender balance - only one female in consortium
- 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 classes
  - 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.
- CONNECT: Gender balance - one female in consortium
  - Open-source repository for sharing code and data

Open Science

- **Reproducible science :**
  - Pros: data sets and codes are easily reproduced and there is willingness to share them among projects.
  - Cons: difficulty to reproduce identical results because of the 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

- Funding tech transfer often hard; no scope for funding on UK side due to budget cap; no option for EiC follow-on funding due to brexit. It is maybe the same for Quebec partners.

- Multiple projects started discussions (since the 2021 Seminar) with industry for new projects and/or technology transfer:
  - Nokia Bell Labs
  - Ericsson
  - OVHCloud
  - Moy Park
  - Cisco
  - Rakuten
  - + other SMEs

Questions

Questions ?