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CHIST-ERA Projects Seminar 2021

Smart Distribution of Computing in Dynamic Networks (SDCDN)

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- ❖ **DRUID-NET: eDge computing ResoUrce allocation for Dynamic NETworks**
- ❖ **DiPET: Distributed Stream Processing on Fog and Edge Systems via Transprecise computing**
 - ✓ Edge and fog computing
 - ✓ Dynamic distribution of computations
 - ✓ Stream processing
- ❖ **CONNECT: COmmunicationN-aware dyNamic Edge CompuTing**
- ❖ **LeadingEdge: Holistic and Foundational Resource Allocation framework for optimized and impactful edge computing services**
- ❖ **SCORING: Smart Collaborative cOmputing, caching and netwoRking paradlgm for next Generation communication infrastructures**



DRUID-NET:

❖ Workload Estimation

- ✓ Device Profiling (logistic regression approach+gradient boosting algorithm or multilayer perceptron layer)
- ✓ Application Profiling (real data sets of 6 IoT applications in smart-building environment - 5 tested regression-based machine learning algorithms for predicting QoS metrics per application)
- ✓ Mobility Profiling

❖ Performance Modeling

- ✓ Hybrid Dynamic Models (black-box system identification algorithms)
- ✓ Queueing Models (Queue model for distributed agents)

❖ Resource Allocation

- ✓ Admission Control (AIMD-like admission controller)
- ✓ Resource Scheduling
- ✓ Task Offloading
- ✓ Control co-design

LeadingEdge:

- ❖ **Pillar 1:** Optimized intra-service resource allocation optimization at the network edge
 - ✓ Edge resource management (cache capacity, computation bandwidth, energy) within each single service
 - ✓ Coping with unknown dynamics that impact decision making
- ❖ **Pillar 2:** Cross-service orchestration at system level
 - ✓ AI driven approaches
- ❖ **Pillar 3:** User-level QoE
 - ✓ OpenAirInterface.org (OAI), Mosaic-5g.io software platforms: Real-time experimentation environment with full 4G/5G functionalities
 - ✓ *guifi.net* community-network infrastructure

SCORING

- ❖ Towards a Tightly-Coupled Computing, Storage and Networking Architecture for NGN
 - ✓ Use case definition, requirement analysis, and KPI identification for 8 different complementary and futuristic use cases
- ❖ Efficient resource allocation in intelligent computing and communication networks
 - ✓ Proposed game-theoretic solutions and incentive mechanisms.
- ❖ Content migration in edge computing environment
 - ✓ Proposed an optimization framework using deep reinforcement learning [IEEE TNSM, minor-revision]
 - ✓ Investigated new approaches to improve QoE for CDN users using Information Centric Networks (ICNs) [GLOBECOM'20]
- ❖ Efficient computing-resource allocation and content caching at the Network Edge
 - ✓ Proposed centralized and distributed heuristics based on a multi-objective optimization formulation [CNSM'20]
 - ✓ Investigated novel approach for computing-service caching based on ICN principles [GLOBECOM'20]
 - ✓ Investigated RNN-based approaches to reduce the operational cost of networks of caches



CONNECT

◆ **Distributed learning at the wireless edge**

- ✓ Update-aware device scheduling
- ✓ Analog distributed gradient descent
- ✓ Over-the-air federated image classification
- ✓ Fully distributed learning: GADDM, Q-GADMM, C-GADMM
- ✓ 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
- ✓ Hierarchical federated learning in VANET



DiPET:

- **Transprecise Object Detection at the edge:**
 - DNN-based object detection
 - Using predicted video content (bounding box size, speed of motion) to adapt the complexity of the DNN [ICFEC'2021]
 - Characterisation of training and classification accuracy as a function of arithmetic precision [SYNASC'2020]
- **Modeling of elasticity of applications**
 - In order to predict placement and scaling of applications
 - Modelling error < 2%
- **Setup of network monitoring in Guifi.net**
 - <https://gitlab.com/rbaig/dipet-nids-dev/-/tree/master/netflow>
- **Anomaly detection using 'Event Detection Engine'**
 - Characterisation of transprecision aspects
 - <https://github.com/DIPET-UVT/EDE-Dipet>



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 the control process of Cyber-Physical Systems and IoT applications**
- 3. Real Dynamic Resource Scaling Extensions for well-known cloud/IoT orchestration software.**
- 4. Disseminating source code repositories; adoption of extensions in Apache Flink, Kubernetes**
- 5. Extension of SDN functionalities to address functions executions in network nodes (P4)**
- 6. AI-based proactive joint placement of computing services, computing stores and content stores**



- 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,...).**
- 2. Architecture design for tightly coupling Compute, Caching and Communication in the Cloud/Network/Fog/Edge/Mist continuum.**
- 3. Network-economic models to support service offering in multi-stakeholder settings Cloud/Network/Fog/Edge/Mist continuum.**
- 4. From Information Centric Networking to Named Function Networking using P4 language.**
- 5. Dealing with uncertainties, information incompleteness and common pool resources**



- 1. Creating dynamic workload estimators, performance models.**
- 2. Creating common open-access pools of data sets for academic and industrial partners**



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 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



DiPET: Gender balance - only one female in consortium

DRUID-NET: Gender balance - 30% female researchers.

Open-source repository for sharing our code (GitHub) and data (Zenodo)

SCORING: Gender balance - 50% female researchers.

Open-source repository for sharing our code and data

CONNECT: Gender balance - one female in consortium

Open-source repository for sharing our code and data



**OA in leading journals often incompatible with Horizon
2020/Europe embargo times**



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



Questions ?