

CHIST-ERA LeadingEdge Project

LeadingEdge

Holistic and foundational resource allocation
framework for optimized and impactful edge
computing services

Topic: SD CDN

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Overview of presentation

- Project facts
- Project objectives and structure
- Partners and expertise
- Main project results to date
- Dissemination actions
- Exploitation actions and sustainability

LeadingEdge facts

- **Topic:** Smart Distribution of Computing in Dynamic Networks (SDCDN)
- **Start date:** April 1, 2020
- **Duration:** 3 years
- **Funding:** 1,01MEuros
- **Coordinator:** Iordanis Koutsopoulos (AUEB-RC)
- **Webpage:** <https://mm.aueb.gr/leadingedge/>
- **Partners:**
 - Athens U of Economics and Business – Research Center (GR) – Coordinator
 - StreamOwl (GR)
 - University Polytechnic Catalonia (ES)
 - University of Oulu (FI)
 - EURECOM (FR)
 - Huawei Lab Paris (FR)

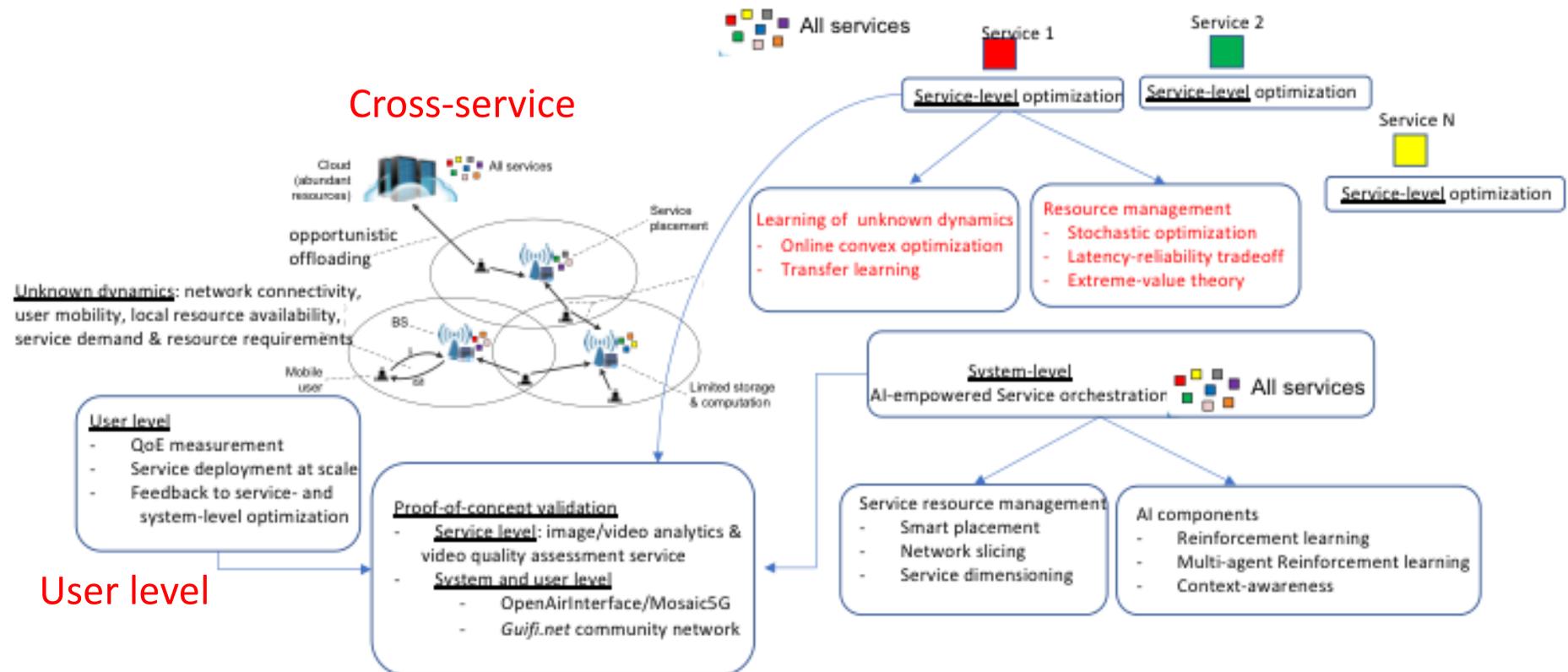


LeadingEdge in brief

- Focus on **Edge Computing** and **Edge Analytics**
- Aspired Impact: ***Leave a firm mark on how services are managed in 5G and Beyond networks***
 - Resource-demanding services using resources at the network edge (for data analytics)
- **Pillar 1:** Intra-service resource allocation optimization at the network edge
 - Edge resource consumption and management (cache capacity, computation bandwidth, energy) within a service
 - Coping with unknown dynamics
- **Pillar 2:** Cross-service orchestration at system level
 - AI driven approaches
- **Pillar 3:** User-level QoE

LeadingEdge overview

Intra service



Project Objectives (1)

- Optimally use edge and cloud resources at service level, through **intelligent task offloading to cloud**, and **dynamic allocation of computation among edge nodes**
 - Stochastic optimization
 - novel usage of caching resources
- Derive fundamental performance limits and devise dynamic algorithms for **maximization of computation rate of data analytics**, with **low latency** and **high reliability**
 - **extreme value theory**
- Overcome unpredictability of service demand, user mobility and edge network topology
 - online convex optimization (OCO) for learning dynamic processes that affect intra-service resource allocation decisions
- AI-based *system-level service orchestrator*
 - **dynamic service placement, network slicing, dynamic resource provisioning** across services, **context-awareness**

Project Objectives (2)

- Service-level proof-of-concept (PoC) validation:
 - Real-time image recognition tool that optimally uses cache, bandwidth and computation resources
 - Two video quality assessment solutions, with different complexity and accuracy and configuration of edge/cloud and cloud/backend resources
- System-level PoC validation:
 - **OpenAirInterface.org** (OAI), **Mosaic-5g.io** software platforms: Real-time experimentation environment with full 4G/5G functionalities for service orchestration
 - the **guifi.net** community-network infrastructure to deploy services at scale and measure perceived user-level QoE



Partners and expertise

- **AUEB-RC** (Prof. I. Koutsopoulos): Applied AI, dynamic resource allocation, caching, optimization, online learning.
- **StreamOwl** (Dr. Savvas Argyropoulos)
- **University Polytechnic Catalunya** (Profs. Leandro Navarro, Felix Freitag): Distributed systems, access to and experimentation with *guifi.net* community network
- **U of Oulu** (Prof. Mehdi Bennis): Learning, edge analytics, drone and vehicular networks
- **EURECOM** (Profs. Adlen Ksentini, Navid Nikaien): 4G and 5G mobile networking and prototyping
- **Huawei France** (Dr. Apostolis Destounis): Online learning, on-device AI

LeadingEdge WP Structure

- **WP1:** Effective learning of unknown dynamics in edge computing: HUA, AUEB-RC, UO
- **WP2:** Low-latency and reliable edge computing: UO, AUEB-RC, HUA
- **WP3:** Optimized intra-service resource allocation within services: AUEB-RC, UO, EURECOM, SOWL
- **WP4:** Service orchestration for optimized inter-service resource allocation and network slicing: EURECOM, UPC
- **WP5:** Experimentation and service deployment over community networks: UPC, EURECOM
- **WP6:** Dissemination and Exploitation: SOWL, ALL

Main Y1 scientific results (1)

- **Advanced models for computation, bandwidth and energy resource management for edge computing**
 - Optimal functional split selection and LTE stream scheduling for cloud-RAN
 - Optimal use of edge resources for iteratively training a large-scale AI model using resource-constrained devices
 - Optimal control of a massive fleet of UAVs at the network edge using mean-field games and neural networks
- **Fundamental performance limits for low latency, high reliability and high throughput in edge computing**
 - Reliability characterization approaches for the Ultra-Reliable Low-latency Communication (URLLC)

Main Y1 scientific results (2)

- **Novel online learning approaches for unknown and dynamic processes undergoing edge computing**
 - Traffic location association with Access Points (APs) and computation offloading as an online learning problems, using Online Convex Optimization (OCO), when traffic demand and channel state are unknown
 - A reinforcement learning (RL)-based approach for content selection for cooperative perception messages for edge vehicular networks
 - A novel communication-efficient, privacy-preserving distributed machine learning framework
- **Novel usage of cache resources at the mobile network edge**
 - Object image caching to reduce computation and communication costs involved in object recognition in Augmented Reality (AR)
- **AI-driven service orchestration and service placement for optimal serving provisioning**
 - An AI-based approach to optimize computing resources for collision detection and avoidance between vehicles for the Internet of Vehicles (IoV)

Dissemination actions

- Seven (7) papers in international conferences
- Eight (8) papers in international journals
- Involvement of consortium members in organization of 2 international workshops and conferences
 - WiOpt 2021 and Mosaic5G workshop
- 1 Tutorial and 2 Keynote presentation in international conferences
 - @IEEE ICC 2020, IEEE GLOBECOM 2020
- Collaboration with 2 research groups out of project
- Dissemination to 3 European projects
 - 6GENESIS project <https://www oulu.fi/6gflagship/>
 - 6G-Brains, 5G-VICTORI (<https://www.5g-victori-project.eu/>)
- Participation in Video Quality Experts Group
- Other internal dissemination actions

Sustainability and exploitation (1)

- **Pillars of exploitation**

- **guifi net:** service deployment and orchestration algorithms and systems are of interest to the guifi.net community network, for service provision
- **Mosaic5G:** EURECOM will make available a subset of experimental development to the larger community via Mosaic5G/OAI opensource code base.

- **Planned actions by industrial partners**

- StreamOwl: develop edge-based versions of the existing video client quality assessment software
- European patents of inventions from the work in the project
- Launch of a follow-up internal project in Huawei to leverage results and examine applicability for 6G AI services
- Software with prototype implementations of resulting algorithms and additional testing in scenarios provided after discussions with teams working more closely to edge computing products

Sustainability and exploitation (2)

- **Software and prototypes**
 - **REDEMON**: a resilient decentralized automated monitoring system of the *guifi.net* Community Network to replace legacy monitoring system
 - A testbed and service environment for experimentation on the guifi.net community network.
 - **PiGeon**: a lightweight platform for deploying QoS-sensitive services in edge clouds built of single-board devices.
 - **Kube5G** : an automated 4G/5G service management and orchestration framework
 - Cloud-Native Agile 5G Service Platform in Kubernetes environment; of high interest for OpenAirInterface (OAI) and Mosaic5G communities for service provision.
- **New services**
 - LoRaMoto: a communications system aimed at helping civilians exchange information in the aftermath of a natural disaster

Thank you!

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