

WIRELESS AND MULTIMEDIA NETWORKING LAB:

Current research on Internet of (Robotic) things and 5G

Pablo Muñoz

Artificial Intelligence (AI) and its applications - Arqus Research Focus Forum in Granada
26th - 28th September 2022

arQus
European University Alliance

UNIVERSIDAD DE GRANADA

TSTC
SIGNAL THEORY, TELEMATICS AND COMMUNICATIONS DEPARTMENT

CONTENTS

University of Granada · Wireless and Multimedia Networking Lab

1. TEAM

2. RESEARCH

   INTRODUCTION

   5G-CLARITY: AI FOR PRIVATE 5G NETWORKS

   6G-CHRONOS: AI IN THE INDUSTRY 4.0

3. FUTURE PLANS & COLLABORATION

1. TEAM

University of Granada · Wireless and Multimedia Networking Lab

The **Wireless and Multimedia Networking Lab** (WiMuNeT, code TIC-235) is formed from people of the Department of Signal Theory, Communications and Telematics of the University of Granada. Visit our website at http://wimunet.ugr.es.



JUAN MANUEL LÓPEZ SOLER
FULL PROFESSOR



PABLO AMEIGEIRAS
ASSOCIATE PROFESSOR



JORGE NAVARRO ORTIZ
ASSOCIATE PROFESSOR



JUAN JOSÉ RAMOS MUÑOZ
ASSOCIATE PROFESSOR



PABLO MUÑOZ LUENGO
ASSOCIATE PROFESSOR



JONATHAN PRADOS GARZÓN
POSTDOCTORAL RESEARCHER



ÓSCAR ADAMUZ HINOJOSA
INTERIM ASSISTANT PROFESSOR (Ph.D.)



JOSE ANTONIO ORDOÑEZ LUCENA
Ph.D. STUDENT



LORENA CHINCHILLA ROMERO
Ph.D. STUDENT



NATALIA CHINCHILLA ROMERO
Ph.D. STUDENT



FÉLIX DELGADO FERRO
Ph.D. STUDENT



JULIA CALEYA SÁNCHEZ
M.SC. STUDENT



PABLO RODRÍGUEZ MARTÍN
M.SC. STUDENT

arQus
European University Alliance

UNIVERSIDAD DE GRANADA

TSTC

WIMUNET

CONTENTS

1. TEAM

2. RESEARCH

   INTRODUCTION

   5G-CLARITY: AI FOR PRIVATE 5G NETWORKS

   6G-CHRONOS: AI IN THE INDUSTRY 4.0

3. FUTURE PLANS & COLLABORATION

2. RESEARCH · INTRODUCTION (I)

Towards 6G networks



6G research challenges identified by Hexa-X project

- 5G is currently accelerating the digitization of economies and society.
- To successfully guide the 6G research to meet the needs of 2030, WiMuNeT focuses its efforts on addressing the following challenges:
  - **Connecting intelligence**: AI is expected to play an important role in 6G networks to boost services management and flexible refinement.
  - **Network of networks**: 6G networks will aggregate a wide variety of resources, including communication, data and AI processing, all of them connected at different scales.
  - **Extreme experience**: the realization of Ultra-Reliable Low-Latency Communication (URLLC) services with the highest possible efficiency is key for Industrial Internet of Things (IIoT) use cases.

2. RESEARCH · INTRODUCTION (II)

University of Granada · Wireless and Multimedia Networking Lab

Research interests

Our main research activity focuses on the design and optimization of solutions for mobile networks, particularly in beyond 5G and 6G. We incorporate AI in our proposals, as well as our extensive experience in analytical modeling to provide a more efficient use of network resources.

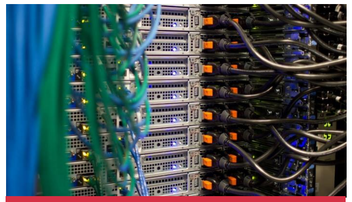


AI



IoT

- NB-IoT
- IoT devices and services
- LoraWAN



Core Networks

- Network slicing
- NFV/SDN
- TSN



Radio Access Networks

- Self-Organizing Networks
- System Level Simulations
- RAN Slicing



Streaming Services

- Characterization
- QoE



5G/6G Lab

- Testbed with real equipment
- LoraWan
- 5G/6G

2. RESEARCH · INTRODUCTION (III)

University of Granada · Wireless and Multimedia Networking Lab

Latest research projects

- 5G/6G networks and communications projects:
  - 5G-CLARITY (Grant number 871428, European Commission H2020) "**Beyond 5G Multi-Tenant Private Networks Integrating Cellular, Wi-Fi, and LiFi, Powered by Artificial Intelligence and Intent Based Policy**" (PIs: Juan M. Lopez-Soler, Pablo Ameigeiras), 11/2019 - 02/2023.
  - 6G-CHRONOS (TSI-063000-2021-28, Spanish Ministry of Economic Affairs and Digital Transformation, NextGenerationEU) "**AI-assisted beyond 5G-6G arCHitectuRe with deterministic netwOrking for iNdustrial communicatiOnS**" (PIs: P. Ameigeiras, J. Navarro-Ortiz), 01/2022 -12/2024.
  - TRUE-5G (PID2019-108713RB-C53, Spanish Ministry of Science and Innovation) "**Towards zeRo toUch nEtwork and services for beyond 5G**" (PIs: Jorge Navarro-Ortiz and Juan M. Lopez-Soler), 06/2020 - 05/2023.
- LPWAN and Internet of Things projects:
  - PREMONITION (B-TIC-568-UGR20, Regional Ministry of Economy, Innovation, Science and Employment, Operational Program FEDER Andalusia), "**low-PoweR sEnsor network for MONItoring envIronmenTal conditions**" (PIs: J. Navarro-Ortiz, J. J. Ramos-Munoz), 07/2021 - 06/2023.
  - ARTEMIS (A-TIC-241-UGR18, Regional Ministry of Economy, Innovation, Science and Employment, Operational Program FEDER Andalusia), "**Architecture for IoT networks oriented to environmental sustainability**" (PI: Jorge Navarro-Ortiz), 01/2020 - 06/2022.

CONTENTS

1. TEAM

2. RESEARCH

   INTRODUCTION

   5G-CLARITY: AI FOR PRIVATE 5G NETWORKS

   6G-CHRONOS: AI IN THE INDUSTRY 4.0

3. FUTURE PLANS & COLLABORATION

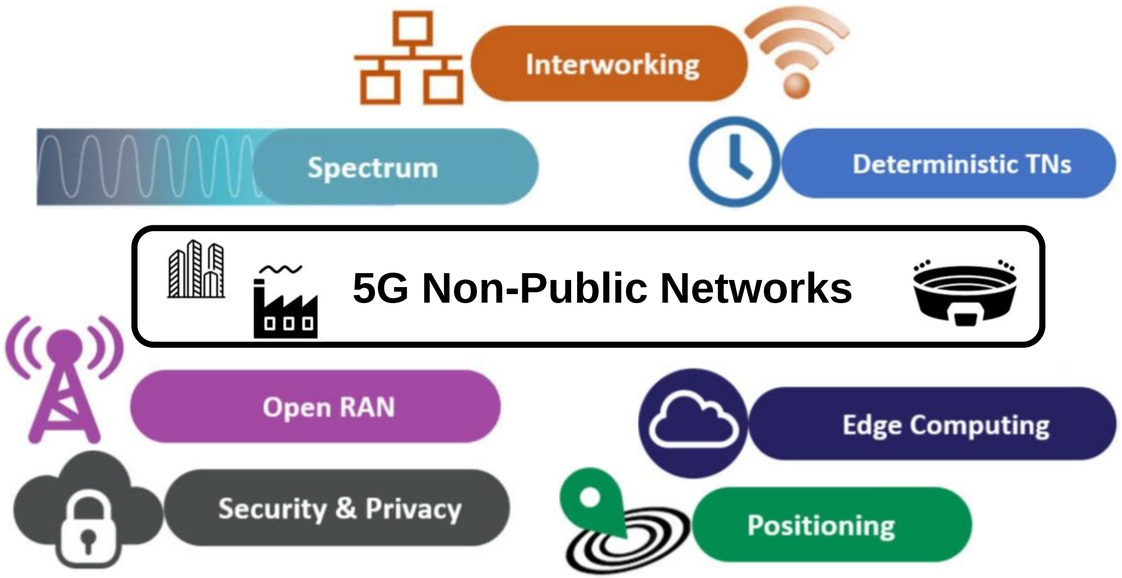
2. RESEARCH · 5G-CLARITY: AI FOR PRIVATE 5G NETWORKS (I)

University of Granada · Wireless and Multimedia Networking Lab

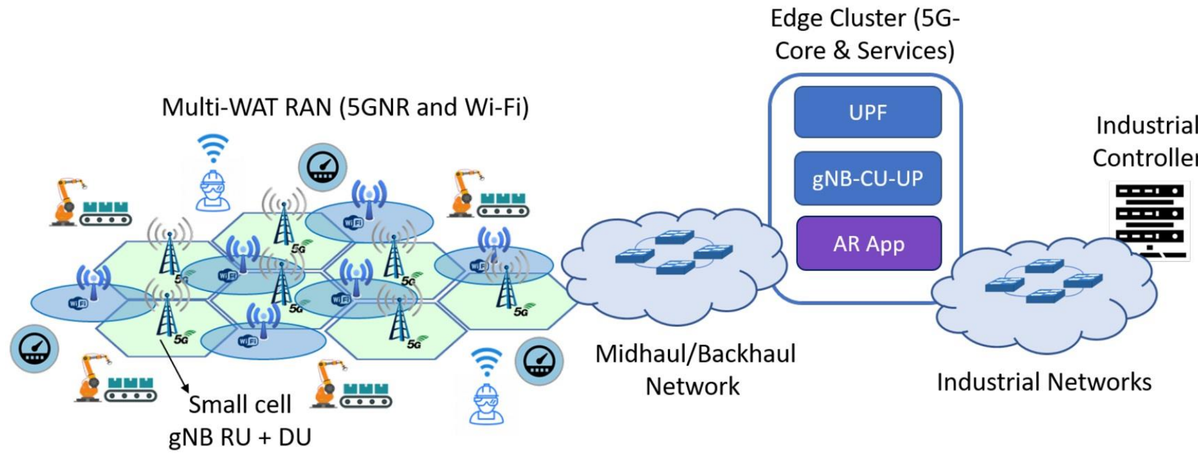
Non-Public Networks for Industry 4.0 and Beyond

- Private networks will play a key role in 5G/6G to enable smart factories with the required better deployment, operation and flexible usage of available resource and infrastructure.

- We analyze standardization, architectures and challenges in private 5G networks [1,2].



- We investigate infrastructure slicing to provide isolation among production lines in an industrial private 5G network [3].
- We investigate AI-based Radio Resource Provisioning in multi-technology private 5G Radio Access Networks [4].
- We investigate Reinforcement Learning for configuring Asynchronous TSN-based 5G Transport Networks [4].



CONTENTS

1. TEAM

2. RESEARCH

   INTRODUCTION

   5G-CLARITY: AI FOR PRIVATE 5G NETWORKS

   6G-CHRONOS: AI IN THE INDUSTRY 4.0

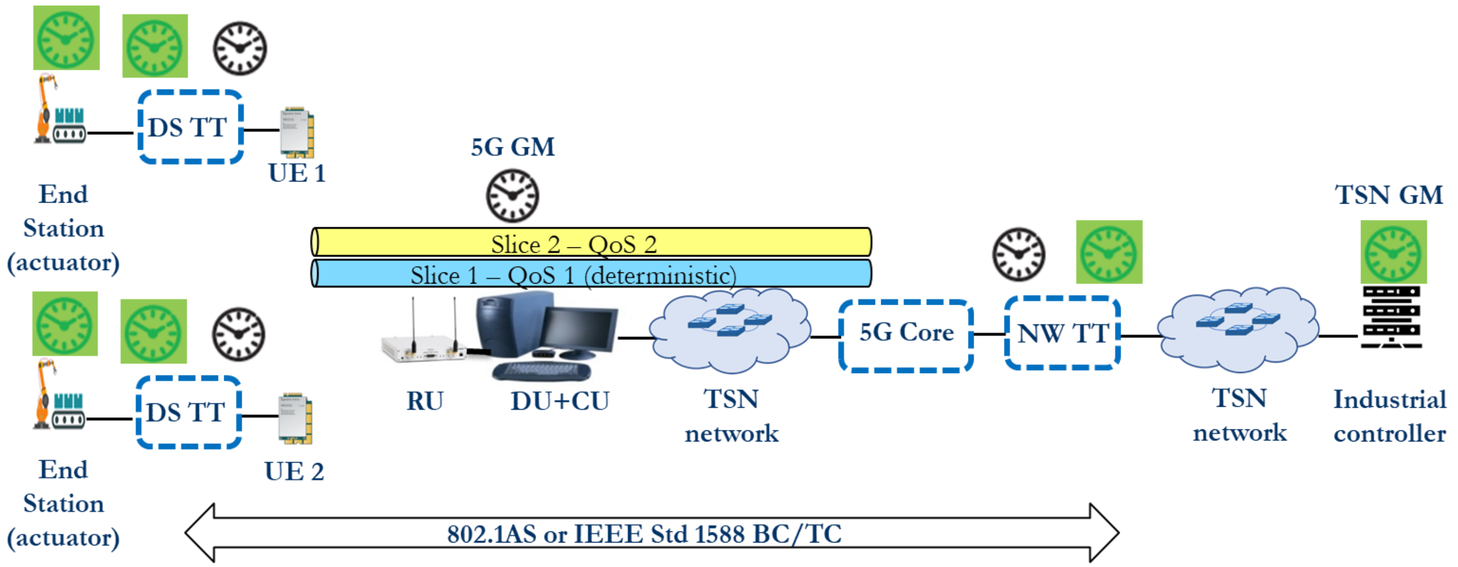
3. FUTURE PLANS & COLLABORATION

2. RESEARCH · 6G-CHRONOS: AI IN THE INDUSTRY 4.0 (I)

University of Granada · Wireless and Multimedia Networking Lab

AI-assisted Beyond 5G-6G Architecture with Deterministic Networking for Industry 4.0

- Targeted scenario: B5G/6G Non-Public-Networks with deterministic latency requirements such as the industry 4.0
- Research goals:
  - Designing synchronous and/or asynchronous TSN-based transport network for private B5G/6G networks to enable slices with deterministic latency.
  - Providing User Plane Function (UPF) support for deterministic networking.
  - Designing an AI-powered platform and algorithms to assist private B5G/6G networks to enable slices with deterministic latency.
- Testbed goals:
  - Experimental validation of the feasibility of a B5G/6G network to act as a set of virtual TSN bridges.
  - Design and development of TSN translator (TT) functionality on the UE side (DS-TT) and on the UPF side (NW-TT).
  - Experimental evaluation of time synchronization solutions (802.1AS, IEEE Std 1588)



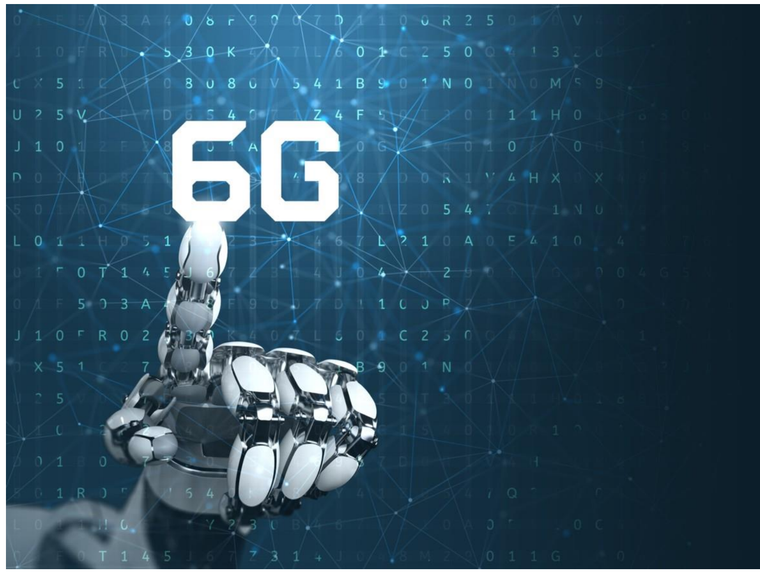
CONTENTS

University of Granada · Wireless and Multimedia Networking Lab

1. TEAM
2. RESEARCH
   - INTRODUCTION
   - 5G-CLARITY: AI FOR PRIVATE 5G NETWORKS
   - 6G-CHRONOS: AI IN THE INDUSTRY 4.0
3. FUTURE PLANS & COLLABORATION

3. FUTURE PLANS & COLLABORATION

- We are open to different forms of cooperation, such as:
  - Participating in European calls such as Horizon Smart Networks and Services Joint Undertaking (SNS JU) calls
  - Exchanging PhD students and academic staff
  - Co-supervising doctoral theses
  - Sharing our testbed with interested parties
- Main research lines are:
  - 5G/6G
  - TSN & Industry 4.0
  - AI & ML in Network Management
  - Network Slicing
  - LoraWAN



REFERENCES

1. J. Prados-Garzón, P. Ameigeiras, J. Ordonez-Lucena, P. Muñoz, O. Adamuz-Hinojosa, "**5G Non-Public Networks: Standardization, Architectures and Challenges**", IEEE Access, 9, pp. 153893-153908, 2021.
2. T. Cogalan *et al.*, "**5G-CLARITY: 5G-Advanced Private Networks Integrating 5GNR, WiFi, and LiFi**", IEEE Communications Magazine, 60 (2), pp. 73-79, 2022.
3. L. Chinchilla-Romero, J. Prados-Garzón, P. Ameigeiras, P. Muñoz, J. M. López-Soler, "**5G Infrastructure Network Slicing: E2E Mean Delay Model and Effectiveness Assessment to Reduce Downtimes in Industry 4.0**", Sensors, 22-1, 229, 2022.
4. J. Ordonez-Lucena et al., "Project H2020 5G-CLARITY (Grant No. 871428): **Deliverable D4.2. Validation of 5G-CLARITY SDN/NFV Platform, Interface Design with 5G Service Platform, and Initial Evaluation of ML Algorithms**", 5G-CLARITY, Jul. 2021.

Thanks for your attention!

More information: wimunet.ugr.es

Contact: pabloml@ugr.es