

Efficient Resource Allocation in 5G and Beyond Networks

Newsletter 2: Project objectives and target – Project progress during the second year

Project objectives and target

The project, ERA5G-Beyond, aims to address the challenges posed by the growing number of connected devices and the need for efficient resource allocation in 5G and Beyond Networks. The project has two main phases. In the first phase, the researchers will explore current promising technologies such as Multi-User Multiple-Input Multiple-Output (MU-MIMO) and Downlink and Uplink Decoupling (DUDe). They will investigate any limitations that may hinder their performance and propose new mechanisms or algorithms to achieve efficient allocation of physical resources. In the second phase, the project will leverage Machine Learning (ML) and Game Theory (GT) to enhance the proposed mechanisms.

In terms of the state-of-the-art and innovation, several research programs in Europe and the United States have already financed projects related to 5G networks. However, the continued growth of users and the introduction of IoT devices necessitate efficient resource utilization. DUDe and MU-MIMO technologies have emerged as promising solutions for resource allocation, and the project aims to further enhance their performance through ML and GT techniques. ML techniques are seen as crucial for addressing dynamic problems in 5G networks, such as real-time distribution of network resources. These techniques, including data mining, big data analysis, and deep learning, can automate network management tasks and optimize network parameters.

During the second year of the project, we mainly focus on the completion of the first phase and the initialization of the second phase of the ERA5G-Beyond project. The research team focus on exploring and evaluating various approaches for DUDe, in order to address the challenges of resource allocation in 5G and Beyond Networks. More specifically the research team focus on user and bandwidth allocation and in power optimization in DUDe networks. Moreover, the research team examines the benefits and potential limitations of MU-MIMO and proposes new mechanisms and algorithms to improve their performance in 5G networks. More specifically during the second year of the project we evaluated user and bandwidth allocation in MU-MIMO 5G networks. The implementation of the first phase laid the groundwork for further research and advancements in the field of resource allocation in 5G and Beyond Networks using ML and GT in the second phase of the project. Additionally, the research team, in the context of phase two of the project, leverage techniques inspired by ML

The research project was supported by the Hellenic Foundation for Research and Innovation (H.F.R.I.) under the “2nd Call for H.F.R.I. Research Projects to support Faculty Members & Researchers” (Project Number: 2440).

and Game Theory GT to enhance the above technologies (DUDe and MU-MIMO) and optimize resource allocation.

The project aims to have a scientific impact by contributing to the foundations of 5G and Beyond Networks. It seeks to improve network capabilities through innovative resource allocation mechanisms, enhancing performance metrics such as throughput, capacity, spectral efficiency, and energy consumption. The economic impact is expected to be significant, with the deployment of these technologies driving productivity growth, creating new markets, and fostering investments in network infrastructure and technology innovations. From a societal perspective, 5G and Beyond Networks have the potential to transform various aspects of society, including the development of smart cities. The project recognizes the need for efficient resource allocation to enable the full potential of these networks in creating interconnected smart cities that enhance the quality of life for residents.

Project progress during the first year

Project progress during the second year

In the following paragraphs we present the project progress during the second year.

WP2: Decoupling in 5G and beyond networks

Based on the extensive state-of-the-art analysis, we targeted to improve existing or propose innovative DUDe algorithms and mechanisms for 5G and Beyond Networks. The algorithms take advantage of the user-centric approach that DUDe follows, offering the ability for users to connect to different Base Stations (BSs) in the uplink and downlink direction. The improved/proposed algorithms and mechanisms are expected to exploit the macro BS infrastructure and more importantly the installed small BSs close to the macro BSs borders. In addition, they take into account the macro and small BSs available resources to determine the most efficient BS (in both directions) that the user should connect to, aiming at improving the overall downlink and uplink data rates and mitigating interference. The work of WP2 led to the publication of at least two conference papers and one journal article.

During the second year of the project in the context of WP2 the following papers has been published:

- Optimizing Network Performance in 5G Systems with Downlink and Uplink Decoupling, Christos J Bouras, Charalampos Chatzigeorgiou, Vasileios Kokkinos, Apostolos Gkamas, Philippos Pouyioutas, 6th International Conference on Advanced Communication Technologies and Networking (CommNet'23), Rabat, Marocco, December 11-13, 2023.
- Bandwidth Optimization Techniques in Heterogeneous 5G Networks Using DUDe, Konstantinos Tsachrelis, Chrysostomos Athanasios Katsigiannis, Vasileios Kokkinos,

The research project was supported by the Hellenic Foundation for Research and Innovation (H.F.R.I.) under the “2nd Call for H.F.R.I. Research Projects to support Faculty Members & Researchers” (Project Number: 2440).

Apostolos Gkamas, Christos J Bouras, Philippos Pouyioutas, 6th International Conference on Advanced Communication Technologies and Networking (CommNet'23), Rabat, Marocco, December 11-13, 2023.

- Optimizing Resource Allocation in 5G Networks through Downlink and Uplink Decoupling, Christos Bouras, Charalampos Chatzigeorgiou, Vasileios Kokkinos, Apostolos Gkamas, Philippos Pouyioutas, 15th International Congress on Ultra Modern Telecommunications and Control Systems (ICUMT) Ghent, Belgium in October 30 – November 1, 2023
- On the Optimization of User Allocation in Heterogeneous 5G Networks Using DUDe Techniques, Konstantinos Tsachrelias, Apostolos Gkamas, Chrysostomos Athanasios Katsigiannis, Christos J Bouras and Vasileios Kokkinos, Philippos Pouyioutas, The 14th International Conference on Ubiquitous and Future Networks July 4 (Tue.) ~ 7 (Fri.), 2023, ECE – Ecole d'ingénieurs, Paris, France & Virtual Conference

WP3: MU-MIMO for improved spectral efficiency

Our work focuses on integrating and utilizing MU-MIMO technology in order to offer improved data rates to a larger number of users. The improvement of the communication system capacity, the enhanced reliability of the communication links and the improved overall spectral efficiency will be achieved using multiple antennas on both ends (user and BS) of the communication link. During the second year of the project, we focused on the design and the implementation of users and bandwidth allocation techniques on MU-MIMO 5G networks. Moreover, we investigate the power consumption of the proposed techniques. The ultimate goal of WP3 is to improve or propose new MU-MIMO algorithms and mechanisms, which will in turn lead to the publication of at least two conference papers and one journal article.

During the second year of the project in the context of WP3 the following paper has been published:

- Evaluation of User Allocation Techniques in Massive MIMO 5G Networks, Christos Bouras, Damianos Diasakos, Apostolos Gkamas, Vasileios Kokkinos, Philippos Pouyioutas, Nikolaos Prodrornos, The 10th International Conference on Wireless Networks and Mobile Communications (WINCOM 2023), Istanbul, Turkey 26 to 28 October 2023

WP4: Machine learning and game theory techniques for network optimization

The purpose of this WP is twofold. On the one hand we plan to evaluate several ML algorithms (supervised and unsupervised) and design/analysis techniques inspired by GT in order to gain

The research project was supported by the Hellenic Foundation for Research and Innovation (H.F.R.I.) under the “2nd Call for H.F.R.I. Research Projects to support Faculty Members & Researchers” (Project Number: 2440).

network experience and optimize the network planning based on predictions and user fairness. On the other hand, we will apply the most efficient ML algorithms and GT techniques on the developed (in WP2 and WP3) DUDe and MU-MIMO mechanisms in order to further improve the spectral efficiency and optimize the overall network performance (e.g. in terms of number of supported devices, achieved data rates, etc.). The work of WP4 will lead to the publication of 2 conference papers and 2 journal articles. During the second year of the project, the two first deliverables of the WP4 have been completed.

WP5: Management and dissemination

This WP aims to meticulously monitor and oversee the progress of all WPs within the project. This includes both the experimental work being conducted and the management of administrative issues, such as coordinating meetings, tracking deliverables, and ensuring timely completion of reports.

Additionally, the administration WP recognizes the importance of effective communication and dissemination of project outcomes. To achieve this, it focuses on maintaining a dedicated website that serves as a comprehensive platform for sharing project updates, research findings, and relevant information. By providing a centralized hub for dissemination, the website helps to enhance awareness, visibility, and understanding of the project's objectives, achievements, and potential impact.

Web Site

<https://era5g.upatras.gr/>

The research project was supported by the Hellenic Foundation for Research and Innovation (H.F.R.I.) under the “2nd Call for H.F.R.I. Research Projects to support Faculty Members & Researchers” (Project Number: 2440).