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DYNAMIC AND INTELLIGENT 6G NETWORKS

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Research Group: Information Technologies Group

The Information Technologies Group comprises 5 full professors, 1 associate professor, 2 assistant professors, 2 postdoctoral researchers, and more than 20 research engineers. The group has demonstrated strong funding capacity: since January 1, 2010, it has been awarded over 30 publicly funded European and national R&D projects and has signed approximately 80 technology transfer contracts. Industry contracts include collaborations with major Spanish telecom operators (Telefónica, Orange, Vodafone, and Cellnex), leading Spanish multinationals (such as Indra), and other prominent technology companies and research centers, including Televés, Optare Networks, Centum Research, Marine Instruments, IMEC, and Gradiant.

The head of the group was a founding member of Gradiant, where he served as CTO for Networks and Applications from 2008 to 2013. Gradiant is currently one of the main agents of IT technology transfer to Spanish industry. The group has published over 200 papers in areas related to this project in international JCR-indexed journals, including Computer Networks, IEEE Transactions on Image Processing, IEEE Transactions on Communications, IEEE Transactions on Wireless Communications, IEEE Transactions on Systems, Man, and Cybernetics, IEEE Transactions on Vehicular Technology, IEEE Transactions on Industrial Electronics, IEEE Transactions on Industrial Informatics, IEEE Transactions on Consumer Electronics, and IEEE/ACM Transactions on Networking, among others. It has also presented numerous papers at leading international conferences such as IEEE ICC, IEEE GLOBECOM, IEEE HPSR, and IEEE MILCOM.

The group operates a unique infrastructure that enables full-campus coverage with a B5G network featuring programmable communications and computing resources. This infrastructure will be open to private-sector third parties, making it an ideal environment not only for basic research but also for technology transfer. It will allow to perform self-provisioning of SIMs and eSIMs, including configuring new SIM cards in the core network for new subscribers, covering both FR1 and FR2 frequency ranges.

Keywords: **Extremely Dynamic Network Environments | Network Intelligence | Distributed Network Computing | 3D Multihop 6G Integrated Networks | Intelligent 6G Orchestration | IA and ML for the Automated Operation of Networks | Intent Based Networking |Data Analytics**

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Research Focus:

The evolution toward 6G networks is driving a transformative shift in mobile communications, enabling ultra-high-speed, intelligent, and globally connected systems. Additionally, non-terrestrial networks (NTN) extend connectivity beyond ground infrastructure by integrating satellites, high-altitude platforms, and airborne base stations with terrestrial systems to deliver seamless global coverage, especially in remote regions. AI-native networks embed artificial intelligence directly into network architecture to enable autonomous, self-configuring, self-healing, and self-optimizing systems.

Realizing this vision requires new modeling and learning paradigms capable of capturing the highly dynamic, heterogeneous, and interconnected nature of those ecosystems. In this context, graph-based representations naturally model network entities (e.g., base stations, satellites, UAVs, users) as nodes and their interactions as edges, enabling the use of graph neural networks (GNNs) for system analysis and control. GNNs are particularly well suited to learning over irregular, time-varying topologies, where traditional grid-based or centralized learning approaches fail to scale or generalize. They enable distributed inference and decision-making by leveraging local neighborhood information while still capturing global structural dependencies. This is essential for tasks such as resource allocation, routing, interference management, and mobility prediction in integrated terrestrial-non-terrestrial networks. Moreover, GNNs support inductive learning, allowing models trained on one network configuration to generalize to unseen topologies, which is critical in highly dynamic 3D network environments.

In this context, Edge intelligence and Mobile Edge Computing (MEC) move computation, storage, and AI processing closer to terminals at the network edge to reduce latency and congestion, enabling real-time services through distributed AI processing, edge caching, task offloading, and cooperative edge-cloud architectures. This infrastructure addresses emerging challenges for compute-intensive distributed computing solutions.

State-of-the-art paradigms for distributed AI processing in 3D aerial networks build on hierarchical and collaborative learning frameworks that exploit the spatial and functional diversity of aerial platforms. These include federated learning adapted to highly mobile nodes, where UAVs, high-altitude platforms, and ground stations collaboratively train shared models without centralizing data, thereby reducing communication overhead and preserving privacy. Split learning and hybrid federated-edge learning approaches further distribute computation across aerial and terrestrial layers, balancing latency, energy consumption, and model accuracy. Multi-agent reinforcement learning (MARL) is also gaining prominence for enabling autonomous coordination among aerial nodes in tasks such as dynamic coverage, trajectory optimization, and resource allocation in 3D space. Together, these approaches support scalable, resilient, and adaptive distributed intelligence across integrated terrestrial–aerial–satellite 6G infrastructures.

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