Ph.D. in Information Technology
Thesis Defenses

May 5th, 2026
At 10:00 a.m.
Aula Seminari Alessandra Alario - Building 21

Mengyao LI – XXXVIII Cycle

RESOURCE TRADING AND ORCHESTRATION IN SECURE EDGE-CLOUD NETWORKS DISTRIBUTED OVER HETEROGENEOUS DOMAINS
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Abstract:

The evolution of modern communication networks is increasingly driven by intelligent and data-intensive applications deployed over heterogeneous, distributed, and highly dynamic infrastructures. Modern networks must integrate edge and cloud computing, terrestrial and non-terrestrial connectivity, and virtualized network functions under strict constraints
related to resource availability, energy efficiency, security, and resilience.
This architectural shift introduces fundamental orchestration challenges, as traditional control and optimization approaches are no longer sufficient to cope with unstable connectivity, heterogeneous resources, and diverse service requirements. Emerging paradigms such as Software-Defined Wide Area Network (SD-WAN)–orchestrated edge–cloud systems, satellite assisted connectivity, and virtualized 5G Radio Access Networks (RAN) further increase system complexity by spanning multiple administrative domains and technology layers. In such environments, orchestration must continuously adapt to dynamic conditions while jointly coordinating computation, communication, and learning processes in a scalable and resource efficient manner.
This thesis investigates resource trading and orchestration in secure edge–cloud networks from a unified perspective aligned with modern AI-enabled network architectures. The research explores how Machine Learning (ML) and Federated Learning (FL) can be embedded into network control loops to enable adaptive decision-making under heterogeneous resource constraints, dynamic connectivity conditions, and multi-domain operational requirements.
The first part focuses on resource-aware model aggregation and de-centralized learning strategies for Federated Learning in SD-WAN-enabled Multi-access Edge Computing (MEC) environments, introducing hierarchical and distributed aggregation mechanisms that improve robustness and scalability under limited wide area connectivity. The scope is then extended to heterogeneous infrastructures through satellite-assisted Space–Ground Integrated Networks (SGIN), where predictive and learning-driven traffic steering enables proactive adaptation to highly dynamic topologies. To support heterogeneous services and multi-operator deployments, economically grounded network slicing frameworks
are developed, combining hierarchical auction mechanisms with region aware resource allocation to balance efficiency, fairness, and operational cost. Security and resilience are further addressed

through the study of Quantum Key Distribution (QKD) networks, where attack-aware routing metrics and progressive recovery mechanisms are proposed to jointly optimize survivability and resource utilization.
Overall, this thesis demonstrates that future AI-based communication infrastructures require unified orchestration frameworks that combine intelligence, economic resource trading, multi-domain coordination, and quantum secure communication. The proposed methodologies contribute scalable design principles for next-generation edge–cloud ecosystems operating under heterogeneous, dynamic, and security-critical conditions.

PhD Committee

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