Thesis Topic 2024

Federated Learning for Beam Management

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1 Abstract

In the context of the emergence of 5G and 6G wireless networks, optimized beam management is essential for effective and precise data transmission, thereby significantly enhancing network capacity, coverage, and signal quality. Given the increasing complexity of these dense and dynamic wireless environments, the integration of Machine Learning (ML) techniques has become a necessary approach [1]. However, despite the significant advancements these techniques have brought to beam management, concerns regarding security and privacy have arisen, mainly due to the centralized nature of data collection and processing, which limits their effective implementation [2, 3]. In response to these challenges, Federated Learning (FL) emerges as a promising alternative, offering a more secure and privacy-conscious method through the decentralization of the learning process.

The main objective of this thesis is to develop a Federated Learning strategy specifically designed for beam management, capable of handling the diversity of data and addressing the challenges posed by dynamic network environments. This strategy aims to enhance the performance of current wireless networks, reduce latency, and preserve data confidentiality, thus aligning with the contemporary requirements of communication systems.

Figure. 1 illustrates the concept of federated learning, highlighting its key role in optimizing modern telecommunication networks, such as 5G and 6G.

2 Keywords

Machine Learning, Neural Networks, Beam Tracking, Signal Processing, Digital Communication, Matlab, Python.

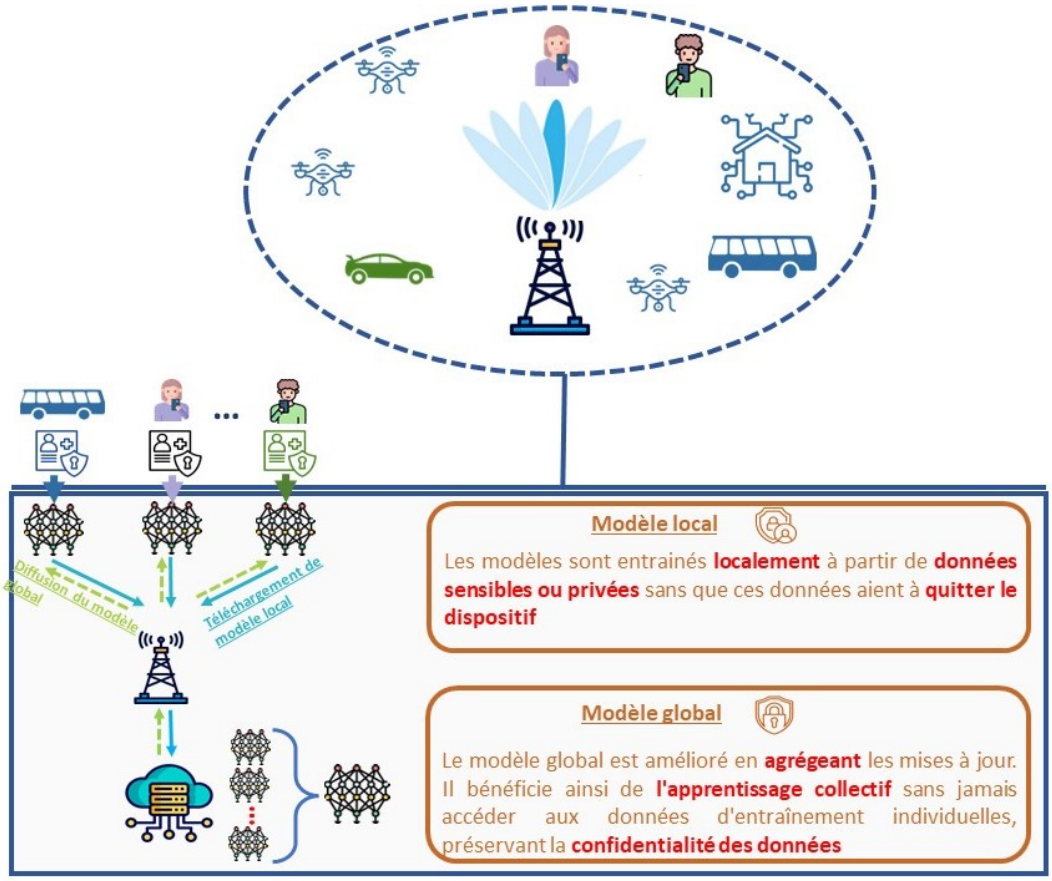

Figure 1: Federated learning for beam management

3 State of the Art

Beam management is a key technique in modern telecommunication systems, allowing for more efficient and accurate data transmission. Brilhantes et *al.* offer a comprehensive review of AI beamforming techniques, highlighting their increasing importance in wireless networks, including 5G and 6G networks [4]. These techniques are crucial to meet the growing demand for capacity, coverage, and signal quality in increasingly dense network environments.

Among these techniques, Federated Learning emerges as a promising solution to overcome security and privacy challenges in wireless network data management. [5, 6] describe the principles, technologies, and applications of Federated Learning, highlighting its potential to decentralize the learning process while preserving data privacy. This approach is particularly relevant in contexts where data cannot be centralized for privacy or security reasons.

Although Federated Learning offers significant advantages in terms of security and privacy, it also presents specific challenges. Liu et *al.* review security challenges in Federated Learning, identifying potential attacks and proposing strategies to mitigate these risks [7]. Consequently, addressing these challenges is essential to create robust Federated Learning approaches capable of dealing with various security threats.

4 Work Program

- ▷ T0 to T0+6 months: Literature Review Phase
  - In-depth analysis of the latest research on beam management of telecommunication systems: Exploring current methods and challenges in beam management for telecommunication systems, including the examination of beamforming techniques and optimization.

- In-depth analysis of the latest research on Federated Learning: Analyzing recent developments in the field of Federated Learning, focusing on applications in wireless networks, advantages in terms of security and privacy, and technical challenges.
- Analyze existing work on beam management techniques, machine learning in wireless networks, and challenges related to security and privacy.

▷ T6 to T24: Design and Development

- Designing the Federated Learning strategy in beam management, considering data diversity and network dynamics.
- Implementing the proposed Federated Learning strategy in a simulation environment.
- Analyzing the results obtained to identify areas for improvement.
- Adjusting and optimizing Federated Learning algorithms to maximize beam management performance and efficiency.
- Evaluating the robustness of the proposed strategy against security threats and privacy issues.

▷ T24 to T30: Optimization and Valorization

- Manuscript writing and defense preparation.
- Writing and submitting scientific publications to share the research results with the academic community.

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