Sujet de stage de fin d'études :

Validation and Evaluation of a Federated Learning Optimization Framework in Fog Computing Environments.

Laboratoire d'accueil : Unité de recherche : LaBRI , UMR 5800.

Profil recherché : niveau ingénieur (bac+5) ou niveau mater 2. Durée du stage : 6 mois (février 2026 – Juillet 2026).
Si vous êtes intéressé(e) par le sujet proposé ci-dessous, veuillez contacter dès à présent par courrier électronique Hicham LAKHLEF (hicham.lakhlef@labri.fr)
Avec :

- Un curriculum vitae à jour ;
- Lettre de motivation ;
- Relevés de notes ;
- Tout document susceptible d'appuyer votre candidature

Internship description:

Federated Learning (FL) is a decentralized approach to machine learning that enables collaborative model training without directly sharing local data, thereby preserving privacy and reducing communication costs. When combined with Fog Computing (FC), which brings computing and storage capabilities closer to connected devices, FL paves the way for intelligent, distributed, and privacy-aware systems in Internet of Things (IoT) environments.

Previous research conducted at LaBRI introduced a dynamic optimization framework based on Mixed-Integer Nonlinear Programming (MINLP) [3] . This framework was designed to mitigate the straggler effect, where slower nodes delay the global aggregation process, and to enhance the overall efficiency of FL within FC. This proposed solution has been further improved through simulation-based performance analysis, yielding promising results in terms of efficiency and scalability.

This internship continues that line of research, focusing on the validation, evaluation, and enhancement of the proposed framework. The intern will perform extensive framework-based simulations using different FL algorithms and frameworks, such as the Flower framework, to validate the model's performance and scalability under various Fog–IoT scenarios, while also providing a critical analysis of the obtained results.

In addition, the work will investigate the integration of new operational constraints, including latency-aware scheduling, privacy costs, network dynamics, node mobility, and security considerations. Beyond validation, the internship also aims to improve and extend the existing framework by refining its optimization strategies and by proposing alternative or complementary approaches to address identified limitations. Potential research directions may include adaptive or multi-objective optimization methods, hierarchical learning architectures, or resource-aware federated learning schemes.

Internship Objectives:
The ultimate objective of this internship is to study Federated Learning in Fog environments and to demonstrate the feasibility, robustness, and adaptability of the proposed model in realistic FC scenarios, while contributing to the advancement of research on distributed, efficient, and privacy-preserving Federated Learning systems. This will be achieved through the following steps:

1. **Analysis and understanding of the proposed framework:** Gain a thorough understanding of FL in Fog environments, the identified straggler effect, and the proposed MINLP mathematical optimization solution. Study the tools and methodologies used for simulation-based performance analysis.

2. **Evaluation of the proposed framework and validation of experimental results:** Define Fog simulation environments to represent various Fog-IoT scenarios. Implement framework-based simulations using Federated Learning platforms such as Flower. Evaluate the performance of the proposed framework and compare the results with the state of the art.

3. **Critical analysis and proposal of improvements:** After validating the solution, conduct a critical analysis to identify potential enhancements. Incorporate additional constraints and objectives, such as latency-aware scheduling, with the goal of making FL in Fog environments more efficient.

References

[1] T. Li, A. K. Sahu, A. Talwalkar, and V. Smith, "Federated Learning: Challenges, Methods, and Future Directions," *IEEE Signal Process. Mag.*, vol. 37, no. 3, pp. 50–60, May 2020, doi: 10.1109/MSP.2020.2975749.

[2] M. R. Bussieck and A. Pruessner, "Mixed-Integer Nonlinear Programming," *SIAGOPT Newsl.*

[3] Ahmed Rjiba, Hicham Lakhlef, Delbruel Stephane, Meriem Afif : "Dynamic Federated Learning Configuration to Mitigate Straggler Effects in Fog Environments", IEEE Conference on Computer Communications (INFOCOM), Tokyo, Japan, 202

[4] Ahmed Rjiba, Hicham Lakhlef, Joachim Bruneau-Queyreix, Meriem Afif: "Federated Learning in Fog Computing within IoT Networks: An up-to-date and comprehensive survey", IEEE Transactions on Network and Service Management

[5] W. V. Solis, J. Marcelo Parra-Ullauri, and A. Kertesz, "Exploring the Synergy of Fog Computing, Blockchain, and Federated Learning for IoT Applications: A Systematic Literature Review," *IEEE Access*, vol. 12, pp. 68015–68060, 2024, doi: 10.1109/ACCESS.2024.3398034.