PhD Thesis Proposal

INTERCHAIN – Blockchain INTEgration foR supply CHAIN interoperability and automation

University/Laboratory : Université Polytechnique Hauts-de-France, LAMIH – UMR CNRS 8201.

Departement : Automation (https://www.uphf.fr/LAMIH/fr/automatique).

Location : Campus du Mont Houy, 59313, Valenciennes.

Starting date : from October/November 2025 (duration: 3 years).

Supervisory team:

Yassine Idel Mahjoub, *Associate Professor*, LAMIH UMR CNRS 8201/UPHF *Yassine.idelmahjoub@uphf.fr*

Tarik Chargui, *Associate Professor*, LAMIH UMR CNRS 8201/UPHF *tarik.chargui@uphf.fr*

Abdelghani Bekrar, *Associate Professor*, LAMIH UMR CNRS 8201/UPHF *abdelghani.bekrar@uphf.fr*

Damien Trentesaux, Full Professor, LAMIH UMR CNRS 8201/UPHF *Damien.Trentesaux@uphf.fr*

1. Scientific context

Subject to the trends of economic globalization, market expansion, escalating competition, and offshoring production, **modern supply chains are becoming more arduous and challenging to manage and control** [Ivanov & Dolgui, 2020]. Recent disruptions such as the COVID-19 outbreak have exposed many vulnerabilities and weaknesses of Supply Chain Management (SCM), revealing a lack of **end-to-end visibility, information traceability, transparency, and, most importantly, a deficiency in collaboration and cooperation** among stakeholders [Pan et al., 2021].

These issues highlight the urgent need for **interoperable and automated supply chains**. In this context, **Blockchain and distributed ledger technologies stand out as particularly promising technologies** to ensure innovation, transparency, trust, and technological development of SCM [Saberi et al., 2019; Idel Mahjoub et al., 2021].

The **ANR JCJC INTERCHAIN project (2025–2028)** aims to propose an infrastructure and methodology integrating Blockchain with existing SCM models and processes. This integration will enable a new level of interoperability and automation through **smart contracts and tokenization**, applied to **supply chains**, and validated on industrial platforms available at LAMIH.

2. Objectives

This PhD thesis will contribute to the objectives of the INTERCHAIN project:

- **Develop a Blockchain-based infrastructure** for supply chain management, ensuring seamless interoperability across participants while guaranteeing scalability, security, and privacy.
- **Design and implement smart contracts and tokenization-based approaches** to enhance supply chain automation and efficiency.
- **Propose formal models and methodologies** (Petri nets, automata, model checking) for ensuring robustness, performance, and reliability of Blockchain-based supply chains.
- **Validate the proposed models** on both real and simulated industrial platforms (LAMIH).

3. Main tasks

The PhD research will be structured in several parts:

1. **State-of-the-art study**
    - Literature review on Blockchain for supply chain interoperability and automation.
    - Identification of current gaps and scientific challenges.
2. **Design of a Blockchain architecture**
    - Specification of requirements and constraints for interoperable supply chains.
    - Development of consensus mechanisms, data models, oracles, etc ….
3. **Smart contracts and tokenization**
    - Definition of supply chain processes to be automated.
    - Development of smart contracts and tokenization models (NFTs, dynamic NFTs).
4. **Experimentation and validation**
    - Implementation of the models on LAMIH industrial and simulated platforms.
    - Performance evaluation (latency, cost, security, efficiency).

Keywords: Blockchain, Supply Chain, Interoperability, Automation, Smart contracts, Tokenization, Industry 4.0.

4. Candidate profile

- Master’s degree (or equivalent) in Computer Science, Automation, Applied Mathematics, or related fields.
- Strong interest in **Blockchain**, **distributed systems**, **supply chain management**, and **Industry 4.0**.
- Skills in programming (Python, Solidity, Go) are required.
- Background in **formal methods** (Petri nets, model checking) and **modeling/optimization of complex systems** is appreciated.
- Excellent written and spoken English is necessary for publications and international conferences.
- Ability to work independently, curiosity for interdisciplinary research, and willingness to collaborate in a research team.

Applications should be sent to *tarik.chargui@uphf.fr* & *Yassine.idelmahjoub@uphf.fr*

1. A detailed **CV** (including education, research experience, and technical skills).
2. A **motivation letter** explaining research interests, academic objectives, and adequacy with the project.
3. Master’s (or equivalent) degree transcripts.
4. Any supporting documents (recommendation letters, internship reports, publications, etc.).

5. References

- Ivanov, D., & Dolgui, A. (2020). *Viability of intertwined supply networks: extending the supply chain resilience angles towards survivability*. International Journal of Production Research, 58(10), 2904–2915.
- Pan, S., Trentesaux, D., et al. (2021). *Digital interoperability in logistics and supply chain management*. Computers in Industry, 128, 103435.
- Saberi, S., Kouhizadeh, M., Sarkis, J., & Shen, L. (2019). *Blockchain technology and its relationships to sustainable supply chain management*. International Journal of Production Research, 57(7), 2117–2135.
- Idel Mahjoub, Y., Bekrar, A., Trentesaux, D. (2022). *Blockchain adoption for SMEs: opportunities and challenges*. IFAC PapersOnLine, 55(10), 1834–1839.
- Chargui, T., Idel Mahjoub, Y., Trentesaux, D. (2023). *Integration of Blockchain and the Physical Internet: A Review and Future Prospects*. SOHOMA Workshop.