Research Master's Project: System Integration of a Hardware Accelerator for the Ethereum Virtual Machine

General Information

Research area: Hardware–software co-design, low-level Linux programming, and *blockchain*
Supervisor: Prof. Pascal Giard <pascal.giard@etsmtl.ca>
Co-supervisor: Prof. Kaiwen Zhang <kaiwen.zhang@etsmtl.ca>
Institution: École de technologie supérieure, Montréal, Québec, Canada
Industry partner: Quantum eMotion

Start date: Summer 2026 or as early as possible

Context

The Ethereum blockchain relies on the Ethereum Virtual Machine (EVM), which is responsible for executing smart contracts. Although the EVM has historically been implemented in software, this approach incurs significant computational and energy costs. These costs have become a major bottleneck for several types of Ethereum nodes, including full nodes, validator nodes, and archival nodes.

Recent research has shown that implementing the EVM as a dedicated hardware accelerator can significantly improve both performance and energy efficiency during smart-contract execution. However, these results have so far been obtained in experimental settings, and the integration of such an accelerator into a real-world Ethereum software ecosystem remains largely unexplored. This gap represents an interesting and impactful research challenge.

This project offers an excellent opportunity to work at the intersection of hardware, software, and *blockchain* technologies, on a topic with strong academic and industrial relevance. It is part of an NSERC Alliance research program conducted in collaboration with our industrial partner, Quantum eMotion, providing an industry-driven perspective.

Project Objectives

The primary objective of this project is to design, implement, and evaluate the mechanisms required to integrate *EVMx*, our hardware EVM accelerator, into the existing Ethereum software stack, while accounting for practical constraints related to deployment in production environments, compatibility, and security. More specifically, the project aims to:

- Design and implement an interface enabling an Ethereum execution-layer client to leverage EVMx.
- Develop a Linux kernel module (*driver*) ensuring efficient communication between the hardware accelerator and the software stack.
- Explore architectural trade-offs related to synchronization, memory management, and security.
- Evaluate the proposed solution using quantitative metrics, including execution throughput, latency, and energy efficiency, and assess its relevance for real-world Ethereum deployments.
- Compare the observed performance against expectations and against a purely software-based execution.

Expected Contributions

In addition to the master's thesis, the project includes technical deliverables spanning multiple domains:

- Systems and hardware architecture: development of a hardware–software communication interface.
- Low-level software: development of a Linux kernel module.
- *Blockchain*: a software library enabling integration with one or more existing Ethereum execution-layer clients, e.g., Geth, Nethermind, Erigon, Besu, or Reth.

Depending on the student's interests, the emphasis may be placed more heavily on hardware, software, or their co-design.

Desired Profile

- Student in electrical engineering, computer engineering, or software engineering.
- Solid background in systems programming (C/C++, ideally under Linux).
- Solid background in hardware design (ideally for FPGAs).
- Interest in computer architecture and embedded or reconfigurable systems.
- An interest in *blockchain* technologies is desirable, but prior expertise is not required.

The following skills are considered assets:

- Experience with the Linux kernel.
- Development of kernel modules (*drivers*).
- Design and implementation of hardware accelerators.

Pascal Giard

Kaiwen Zhang

Supervision

Supervision will be provided by Professors Pascal Giard and Kaiwen Zhang. Dr. Zhang is a professor in the Department of Software and IT Engineering at ÉTS. His research interests include blockchain technologies, publish–subscribe systems, and massively multiplayer online games. His expertise spans distributed systems, networking, and data management. Dr. Giard is a professor in the Department of Electrical Engineering at ÉTS. His research focuses on the efficient implementation of digital systems, from algorithm design to software and hardware realization.

The selected candidate will join a team of graduate student researchers working on closely related topics.

Funding and Duration

The project is funded for a duration of two years and includes financial support for the student's stipend as well as research-related expenses.

Location

ÉTS is located in Montréal, Québec, Canada. Often described as an appealing blend of North American and European culture, Montréal is a safe, multicultural city with a high quality of life and a relatively affordable cost of living. It is the most bilingual and trilingual city in North America: over 50% of Montréalers are fluent in both English and French, and more than 20% speak three or more languages.

Since 2016, Montréal has consistently been ranked the best student city in North America by Quacquarelli Symonds. The city is also well known for its quality of life, proximity to both peaceful rural landscapes and exciting ski resorts, and its vibrant neighborhoods and green spaces. Located in the heart of the city, the ÉTS campus is easily accessible by bicycle or public transportation. Approximately 1,100 students live in the university residences, which include furnished studios and apartments with heating, electricity, and unlimited Internet access.

Since its founding, ÉTS has pursued a mission deeply rooted in all of its activities: addressing the needs of industry, which requires engineers with not only strong theoretical foundations but also practical expertise. To fulfill this mission, ÉTS maintains a unique partnership with the business and industrial sectors, from small enterprises to large corporations. It distinguishes itself from other Québec universities through its applied education model and its research activities conducted by and for industry.

Interested?

Interested candidates should submit their CV, academic transcripts, contact information for appropriate references, and a brief statement of interest (maximum one page) describing how their background is relevant to this project.

Contact: Prof. Pascal Giard <pascal.giard@etsmtl.ca>
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