Applications Of Blockchain Technology To Distributed Computing In High Energy Physics

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Abstract

The HEP software community has identified scalability, complexity, and cost as barriers to advancing high-performance computing in high-energy physics. We intend to address these issues by pulling technology from other domains, such as artificial intelligence, traditional financial technology, web3, and blockchain. By combining computational systems from other domains with existing HEP software, the HEP software community can share costs, pool resources, and aggregate computation power with other computational domains addressing these issues.

In this poster, we will describe the current status and design of our blockchain system which leverages existing open source software technology and web3 for generalized high-performance computing and its application to high energy physics and AI. Our computational infrastructure using comprises a decentralized blockchain system that passes messages between computational nodes, implemented as docker/OCI containers. We use an the end-to-end principle to place policy controls at the endpoints, drastically simplifying computational complexity and removing barriers to international resource sharing between institutions and professional domains.

To support HEP workflows, we are integrating the streaming network with a computational node that uses the KEY4HEP framework to include software commonly used in HEP, such as ROOT, Gaudi, and Podio. We have designed the system to allow easy integration with software-as-a-service systems such as AI providers such as ChatGPT or OpenLlama. We have designed the system to be scalable both upward, allowing the creation of computational networks of the scale of the Bitcoin computation network, and downward, allowing the creation of simple ad hoc distributed computation systems. An open-source prototype of our work is available on GitHub, and we are seeking users and developers from the HEP community.

Motivation

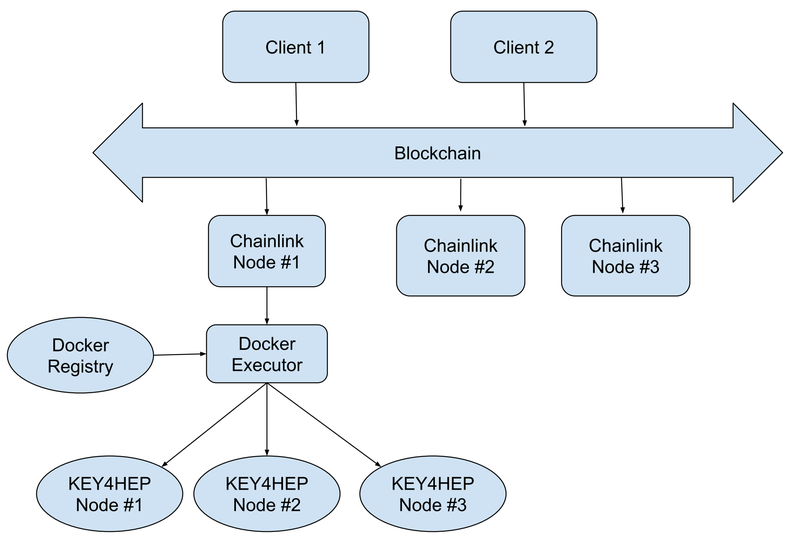
The motivation for this project is to apply high performance computing in quantitative finance and cryptocurrency mining to high performance computing problems. The typical investment bank has a team of several hundred people (half with STEM Ph.D.'s) doing quantitative finance.In the cryptocurrency world, there are vast networks of computing systems that are doing cryptocurrency mining.

Communities

The project will need to combine expertise and systems from three different communities, and will use Hong Kong has a location to connect these three communities

- HEP Physics - The HEP physics needs large amount of computing power and tools to allow quick and easy use of computational resources. There is also the need for funding for development. HEP prioritized working systems and dislikes hype and future promises.
- Traditional quantitative finance - In traditional quantitative finance there is the need to do complex mathematical calculations to run banks. This sector has a lot of funding resources, and project funding is based on regulatory needs (i.e. regulator stress tests). Technical knowledge very high as many people in this field have STEM backgrounds.
- Cryptocurrency - This community is interested in creating the next big thing. There are people with funding resources but funders often have uneven levels of technical expertise, but resources are allocated based on hype and spin. Operating massive clusters of computer system. Bitcoin is the world's biggest and most inefficient computer systems. Because the goal is making money and not technology, the incentives are that often projects with little or no merit are being funded

Architecture and Implementation



Blockchains have high latency and low speed message passing. Typical speed is one message every ten seconds. However, goal is to compensate with low latency by high parallelization Need scalability going up and down. The architecture will bootstrap the system with small clusters and then link the clusters worldwide

In response to messages sent down the database, the server will execute a docker container using KEY4HEP distribution then using the blockchain to send commands to run the software. Different domains can have different software packages and compute nodes, and the benefit is with having a global blockchain is that you can then send messages between different domains.

Current Status

- All source code available on github via open source license
- Now creating simple proof of concept with KEY4HEP calculation node and connecting to blockchain via Chainlink server
- Thinking about security and authentication
- Use a local blockchain for small scale physics calculations and then scale upward

Target workflow modes

- Run the same calculation across multiple nodes to see if the calculation is correct. This is the typical mode for bitcoin which is the world's largest computational network, but the world's stre inefficient computational network
- Run different calculations are performed on different nodes (monte carlo calculations and parameter searches)

Example problems

- Parameter searches - Parallel computations across a large dimensional space - Optimization, Monte carlo and diffusion process with complex dynamics
- AI searches - Run problem against large numbers of AI models and choose the "best" answer
- GPU resource allocations - AI workflows require dedicated allocation of memory bandwidth to problems
- FPGA / Quantum computing - Once you abstract the calculation node then you can replace with quantum optimization system or dedicated hardware computation node

Access control and resource management

Access and resource management will be layered on top of the message passing system. We are working on basic infrastructure and will work on access and resource management later. In a blockchain system, each job and each computation node will have its own private key, and blockchains have mechanisms for sending a message on the network, and the ability to charge for computation.

Contact

Source code available at:
https://github.com/joequant/blockchain-hpc

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