Poster Abstract: Serverless-Enabled Permissioned Blockchain for Elastic Transaction Processing

Byungsoo Oh
KAIST
Daejeon, Republic of Korea
bsoh@kaist.ac.kr

Daeyoung Kim
KAIST
Daejeon, Republic of Korea
kimd@kaist.ac.kr

Abstract

To overcome the performance limits of purely decentralized blockchains, off-chaining models for compute and storage have been studied recently. Serverless computing offers increased elasticity and scalability in executing microservices in event-driven manner, making it proper fit for off-chain computation tasks. In this work, we present a serverless-enabled off-chaining model for permissioned blockchains with some noticeable early results.

CCS Concepts • **Applied computing → Event-driven architectures**; • **Computer systems organization → Cloud computing**.

Keywords permissioned blockchain, serverless computing, off-chain computation, Hyperledger Sawtooth

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1 Introduction

Permissioned blockchain has recently drawn attention from various industry domains. Meanwhile, proliferation of permissioned blockchain has led to increased diversity in the level of computational requirements for execution layer. For example, while some tasks require simple read or write operations, there has been increased demands for processing complex conditional logic, which is compute intensive [1]. However, computation model where each distributed node has to compute state transition and have consensus on every transaction causes severely low throughput at scale. This is exacerbated if the degree of concurrent requests is high or a node has limited compute resources.

To tackle such problem, off-chaining models [2], which offload compute tasks to external nodes have been proposed. The key to this approach is to incorporate trusted centralized computing nodes that execute the transactions. Study of off-chaining is still in its nascent steps and especially lacks discussion about practical system deployment models and related empirical studies. Current system deployment models for off-chaining are primarily based on running monolithic services in dedicated servers. However, this approach has the following limits: (1) Overheads of managing infrastructure such as initial configuration and resource provisioning, (2) cost ineffectiveness caused by relatively low resource utilization, and (3) difficulty in scaling the monoliths in response to concurrent requests.

In this paper, we propose a novel off-chaining computation model leveraging serverless computing. Serverless computing is a cloud service that allows users to launch stateless microservices in an event-driven manner, while resource provisioning and scaling are handled by cloud providers [3]. With these properties, users can focus on developing business logic as a cluster of lightweight functions and are charged only for the deployment of on-demand functions. In this work, we examine how serverless computing can be used as an off-chain execution layer to address the aforementioned limits of current deployment models.

2 System Design

We present system architecture of our proposed blockchain model. Our architecture is based on Hyperledger Sawtooth [4]. As illustrated in Figure 1, our system consists of the following components:

- **Client**: Creates batches of transactions and sends them to a *validator* through the REST API. Access control and a workload generator are included.
- **Validator**: Requests *transaction processor proxy* to execute batches of transactions, and handles persistence of blocks and states, networking, and consensus.
- **Transaction processor proxy**: Handles incoming transactions via *transaction listener* by supporting a hybrid execution model of on-chain and off-chain computations. Depending on the computational requirements or demands for decentralized consensus, transactions

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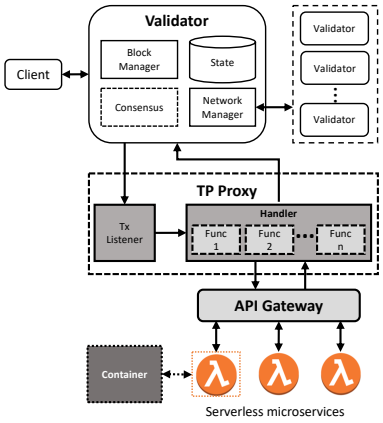


Figure 1. System architecture.

can be processed on or off the chain. Transactions that require robust verification among participating nodes are executed through normal consensus protocol (on-chain compute). On the other hand, compute-intensive tasks with weakened security requirements are carried out by invoking serverless microservices through the API gateway (off-chain compute).

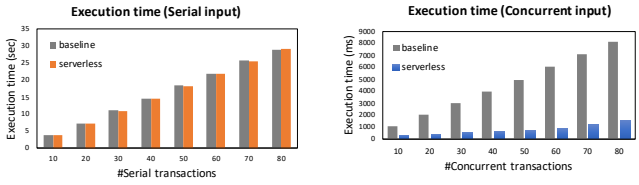
- **API gateway and serverless microservices**: API gateway invokes the corresponding function instance. Given input states and parameters, a stateless function computes state transition and returns output states.

3 Experiments and Preliminary Results

We have implemented a prototype system by extending Sawtooth and developing AWS Lambda [5] functions. Our experiments on this prototype are aimed at understanding the performance impacts of serverless execution layer and gaining insights for proper design decisions. In particular, we demonstrate that our off-chaining model is effective for scaling with negligible overheads. For our workload, we use *Intkey*, a benchmarking transaction processor of Sawtooth. This workload consists of simple operations to manipulate key-value pairs.

We deployed our blockchain nodes in four AWS EC2 instances (commodity hardware resources) while AWS Lambda is configured to use 512MB of memory and reserves 200 concurrent instances per function. With these settings, we measured transaction execution time with respect to the number of serial and concurrent requests. As our experiments are targeted for centralized execution model, we deployed a transaction processor container which communicates with the machine running a Sawtooth node locally as our baseline model. For serial requests, transactions are launched periodically one by one. On the other hand, concurrent loads are generated using threads. Throughout our experiments, each transaction is encapsulated in one batch.

Our early experimental results reveal that performance overheads of communications with external cloud services



(a) Serial requests **(b)** Concurrent requests

Figure 2. Transaction execution time.

is negligible for processing normal serial input (Figure 2a). Moreover, as shown in Figure 2b, our model shows superior results when processing parallel bursts of input. This is because in response to parallel requests to API gateway, loads of function instances are invoked in parallel. Exploiting parallel execution model enables significant performance gains for scaling. While level of parallelism for baseline is 3.18, it is 17.78 for serverless model on average.

4 Conclusion and Future Work

In this work, we propose a novel off-chain compute model using serverless framework. Event-driven nature of serverless functions coupled with supports for parallel invocations lead to increased elasticity of off-chain transaction executions. To improve on the robustness of our model, we will study the performance with diverse tasks and workloads and examine security aspects of off-chain model for permissioned blockchain.

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