Demo Abstract: CIDDS: A Configurable and Distributed DAG-based Distributed Ledger Simulation Framework

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ABSTRACT

Directed Acyclic Graph (DAG) based Distributed Ledger Technologies (DLT) such as IOTA Tangle has been proposed to address the inefficiencies of traditional blockchains, including the issues with scalability, high resource consumptions, and the increasing transaction fees. Despite the promising features introduced by IOTA, the properties of DAG-based distributed ledgers are not yet comprehensively studied. In this work, we propose CIDDS, a configurable and interactive DAG-based DLT simulation framework. CIDDS enables the user to perform large-scale simulations with thousands of nodes and to investigate different characteristics of the network under controlled conditions.

CCS CONCEPTS

• **Computer systems organization → Peer-to-peer architectures**;

KEYWORDS

Distributed Ledger, Directed Acyclic Graph, IOTA, Tangle, Blockchain, Simulation

1 INTRODUCTION

The increasing popularity of blockchain technologies such as Bitcoin and Ethereum highlights their issues with scalability, long confirmation time, high transaction fees and a high waste of resources required for mining the blocks. DAG-based solutions, such as IOTA Tangle [4], have been proposed to address these issues. However, understanding the different properties of proposed DAG-based systems plays a critical role in the widespread adaptation of such DLTs. We propose CIDDS (*Configurable and Interactive DAG-based Distributed ledger Simulation framework*), a configurable simulator for replicating DAG-based distributed ledgers that enables the users to simulate large-scale DAG networks to study and compare the behavior of the simulated network under different configurations. We designed CIDDS to be highly scalable and flexible. Furthermore, we provide a *fast-forwarding* feature so that the system can perform the simulation ahead of time in large scale.

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2 RELATED WORK

IOTA Tangle is currently the major DAG-based DLT [4]. IOTA project offers a demonstration tool for simulating a simple tangle with up to 500 transactions[1]. Also, IOTA foundation published two whitepapers with the simulation results of a discrete [1] and continuous [2] model of the tangle, but the simulation is not publicly available. [3] proposed a solution to create the simulation properties as described in the whitepapers. However, [3] also limits the number of transactions only to a few thousand and the transaction issuing nodes have limited configuration options. We offer a configurable and scalable simulator following the behavior of Tangle as described in the whitepapers, where nodes represent IoT devices issuing microtransactions.

3 PROPOSED SOLUTION

Figure 1 demonstrates the system architecture of CIDDS. The user utilizes the web-based user interface for passing the simulation configuration to the process orchestrator, which is responsible for bootstrapping and executing the simulation. The user can configure the following parameters: the number of nodes, the number of transactions (n), the transaction rate (λ), the level of randomness (α) and the tip selection algorithm. The transaction rate refers to the average number of incoming transactions per unit time âĂŞ the unit time is different from the actual time and only indicates which transactions have arrived after each transaction. The level of randomness is a configurable parameter to ensure that the system performs the tip selection on the DAG uniformly. Because in a DAG-based ledger tip selection for approval is vital for every incoming transaction, we offer two tip selection mechanisms: Uniform Random Tip Section (URTS) and Markov Chain Monte Carlo Tip selection (MCMC). The mentioned parameters and tip selection algorithms are discussed in details in the Tangle whitepaper [4].

Once all the required parameters are provided, the orchestrator spawns individual processes simulating the nodes that issue transactions based on the transaction rate and the randomness. The instantiated nodes run in parallel. We employ a model based on Poisson point process for randomly creating transactions which are realistic to the manner that nodes with less computational resources issue transactions. At the moment, for the sake of simplicity, the simulator skips the necessary computation of Proof-of-Work when issuing transactions. Then, the specified tip selection algorithm is used by the processes to approve transactions in the tangle. The simulator also employs fast-forwarding, which is first introduced in *VIBES*, a simulation framework for Bitcoin-like blockchain systems [5]. By using the fast-forwarding feature, the nodes request the orchestrator's permission to skip ahead in time. In the case, that

[1]https://simulation1.tangle.works/

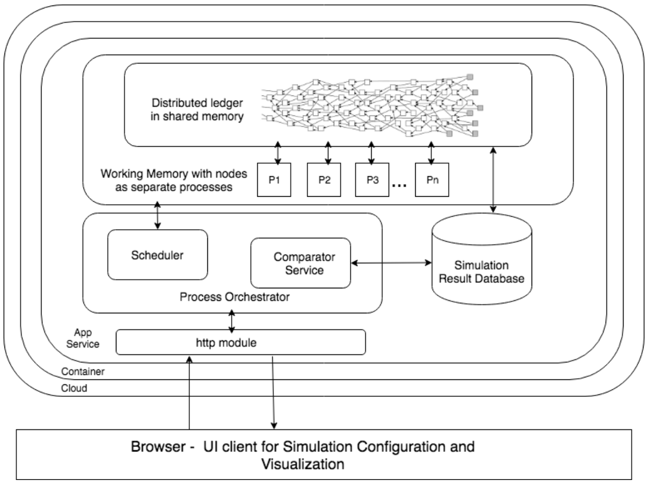

Figure 1: CIDDS system architecture.

orchestrator recognizes fast-forwarding to be conflict-free for the system, the orchestrator issues a time-stamp in the future which nodes use to issue more transactions. These transactions create a DAG in the shared memory which is also visualized for the user in the web-based UI. As the DAG grows in size, the system can store the DAG in the local database for future references. Beside the DAG, the system provides simulation outcomes such as the number of unapproved tips and the number of approved transactions with approval confidence. The simulator can save the simulation outcome to compare the outcome of different parametrized simulations.

We open-sourced the simulator, and the project is publicly available[2].

4 SOFTWARE DEMONSTRATION

To demonstrate the CIDDS, we execute two sample simulations. The first simulation is initiated with the following parameters: $n = 100$, $\alpha = 2$, $\lambda = 2$ and the tip selection algorithm is URTS. Figure 2 presents the resulted DAG. This simulation took 49.2-time units and resulted in 3 unapproved tips.

The second simulation is initiated with the following parameters: $n = 100$, $\alpha = 2$, $\lambda = 2$ and the tip selection algorithm is MCMC. Figure 3 shows the generated DAG. This simulation took 46.7-time units and resulted in 11 unapproved tips. The user can easily change the simulation configuration and especially increase the number of transactions to significantly higher values. We demonstrated examples with smaller configuration parameters due to lack of space for including larger DAGs.

5 CONCLUSIONS

In this paper, we offer a design and implementation of a scalable and configurable simulation framework for DAG based distributed ledgers. Our approach simulates the behavior of IOTA Tangle regarding the creation of the DAG and approval of the transactions.

[2] https://github.com/i13-msrg/cidds

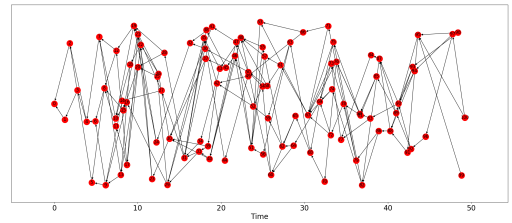

Figure 2: First simulation with URTS Tip selection.

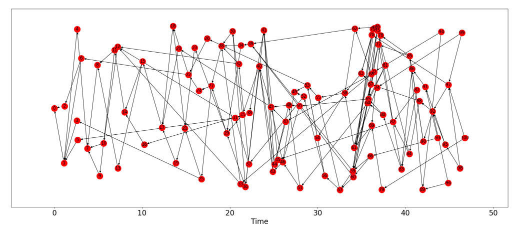

Figure 3: Second simulation with MCMC Tip selection.

As part of our future work, we plan to extend the simulator with attack simulation functionalities where the effect of malicious devices can be investigated.

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