An investigation tool for BESU permissioned blockchain performance.

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Permissioned blockchains allow individuals and consortia to create their own blockchain network and to manage every single aspect of it. For the intended purposes, the consortium aims at optimizing its permissioned blockchain, in terms of performance (which is reflected in the maximum throughput) and load distribution among the nodes on the network. In a permissioned blockchain, one bad performing node can be removed, their number can be tuned and transaction load can be set and ruled in order to optimize blockchain performance. It is therefore essential that the consortium adopts monitoring and benchmarking tools, in order to identify any anomalies in the network and remedy them. Tools such as Graphana, for example, show network activity while Caliper allows you to measure performance in terms of transaction latency and throughput. Values that deviate from those expected are a symptom of anomalies in the configuration of the network or of the individual machines. However, these tools fail to dive into the details that allow you to identify the causes of anomalies.

In our recent work [1] we presented a performance analysis tool capable of providing detailed measures of the single transaction. The tool was developed with the aim of allowing the analyzer greater control over the settings and the possibility of carrying out measurements in completely customizable conditions. Using the tool, a set of tests were carried out on a real consortium's permissioned blockchain where nodes are maintained by different independent public organizations in various geographic sites. Such configuration sets up real working conditions where a permissioned blockchain is not ruled and run by a single entity. The consortium's permissioned blockchain is based on Hyperledger BESU and implemented through Docker technology. The IBFT 2.0 consensus protocol provides validator nodes that, in a round-robin fashion, collect transactions into blocks and propose blocks to other validators. Empty blocks can be validated as well and added to the chain. Since the network is private and permissioned transactions are free, the gas price has been set to zero.

The tool is developed in Java and allows the automatic sending of ethereum transactions to the blockchain network on the basis of the pre-selected configuration, which includes the possibility of setting the transaction send delay, the transaction number, a timeout, the communication protocol (either HTTP or Web socket), the set of nodes' addresses (IP), the port number, the set of

sender keys, the number of nodes to be contacted, the number of senders, and the sending strategy (in parallel or by rotation). The Smart Contract code we used for testing is a standard one. Tool's results has been compared for validation with those of "Hyperledger Caliper", used as a benckmark tool for analyzing blockchain performances (its measurements include Read latency, Read throughput, Transaction latency and Transaction throughput).

The tool was then used to evaluate the performance of the consortium network and to detect any anomalies. To do this, a number of tests were organized, the first results of which were published in our previous work. The experiments involved sending a sequence of a number of transactions separated in time by a delay. The tests were performed with different sending rates, keeping the total sending time constant at 100 seconds. The sending rates were 0.2, 1, 2, 10, and 100 transactions per second (TPS).

The tool returns the data for each transaction in serialized form for each test. These are: the sending time, the nonce, the block registration time, the block height, the validator address, and the sender address. As a summary, it also provides some statistical values. The results show that the performance of the network under consideration degrades in terms of average latency and throughput beginning at 2 TPS, because average latency increases with higher send rates. As a result, an anomaly is discovered for transaction send rates of 2 TPS and higher.

The output data from our custom benchmark tool allows for transaction-by-transaction analysis. An in-depth investigation into the causes of the anomalies reveals that transactions are not distributed evenly across blocks, but are concentrated in one block every two. This is already observed at 2 TPS, whereas at 100 TPS, one block is validated every two blocks with no transaction inside. The test results confirmed that the validators for the next block are chosen using a simple rotation. Because of the regularity of the validators' sequence, the nodes that mine blocks with few or no transactions are always the same two. These validators insert a limited amount of transactions per block in a systematic manner and do not confirm transactions in blocks at rates of 10 and 100 TPS. This behavior is repeated even if that nodes are selected as the recipient of the transactions sending.

As a result, the tool enabled us to pinpoint the source of the performance degradation or an anomalous configuration of two network nodes. The tool can then be used as an investigation tool for consortium blockchain networks to identify the root causes of any anomalies in network performance.

References

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