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MDLB: a metadata dynamic load balancing mechanism based on reinforcement learning

Key words: Object-oriented storage system; Object-oriented storage system; Dynamic load balancing; Reinforcement learning; Q_learning

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Motivation

- The existing algorithms use only metadata access delay to represent the metadata server (MDS) load, and it is a challenge to consider other delay attributes of the MDS itself.
- The current algorithms based on dynamic hashing consider the load change with time, but the training parameters in the distance function are fixed, which makes the algorithms unable to dynamically adjust the server load and causes the algorithms to lack dynamics.

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Main idea

- Based on the existing dynamic hashing based metadata load balancing algorithm, we introduce the relevant adjustment parameters of reinforcement learning (RL).
- When applied to Hadoop's HDFS File System, by introducing the Nginx proxy, the system resource utilization and access latency of the MDS are quantified, considering the performance difference of the NameNodes. In this way, the system has dynamic load balancing capabilities, and the load of each NameNode can be automatically adjusted without manual intervention.

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Method

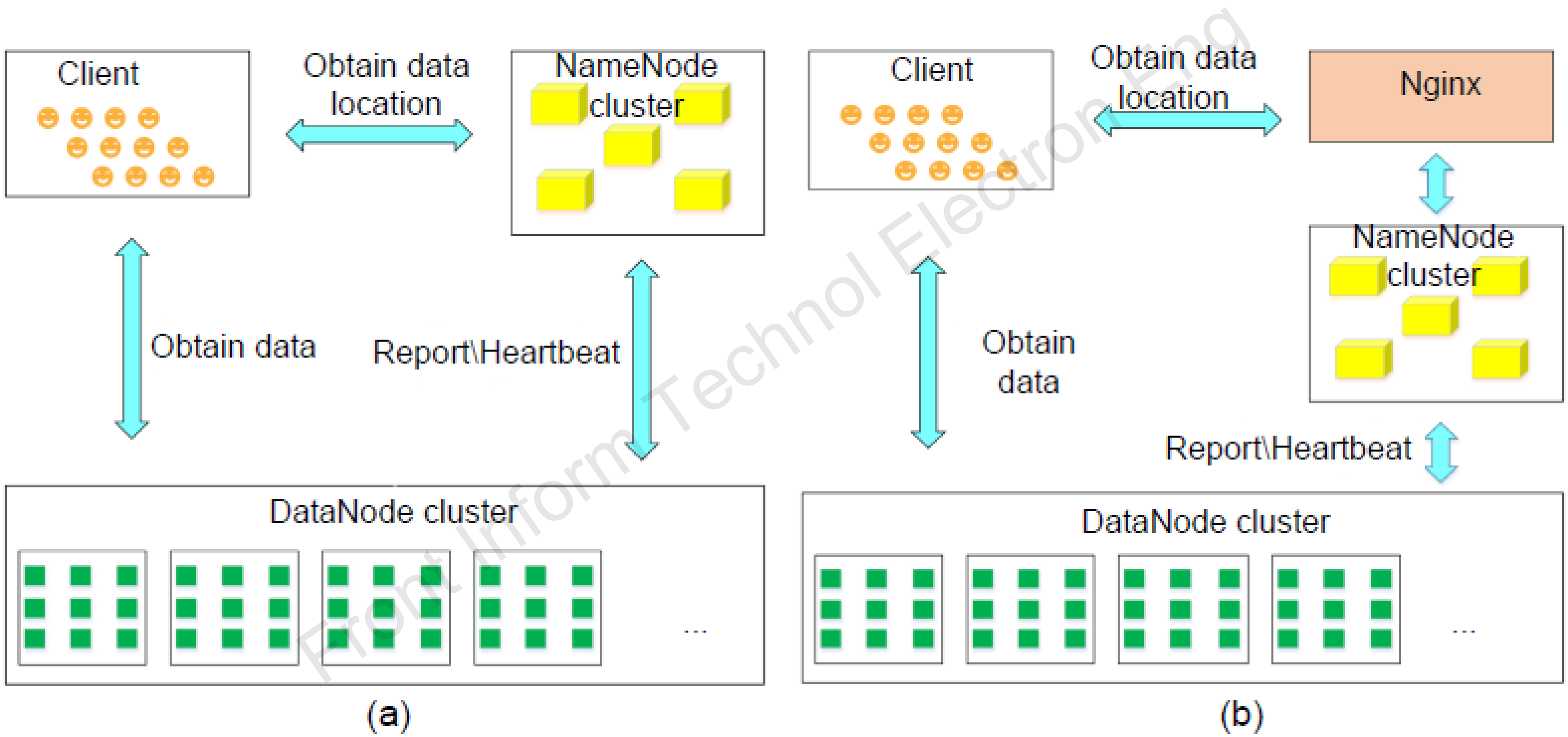

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Fig. 2 Architectures of the HDFS Federation strategy (a) and our improved algorithm (b)

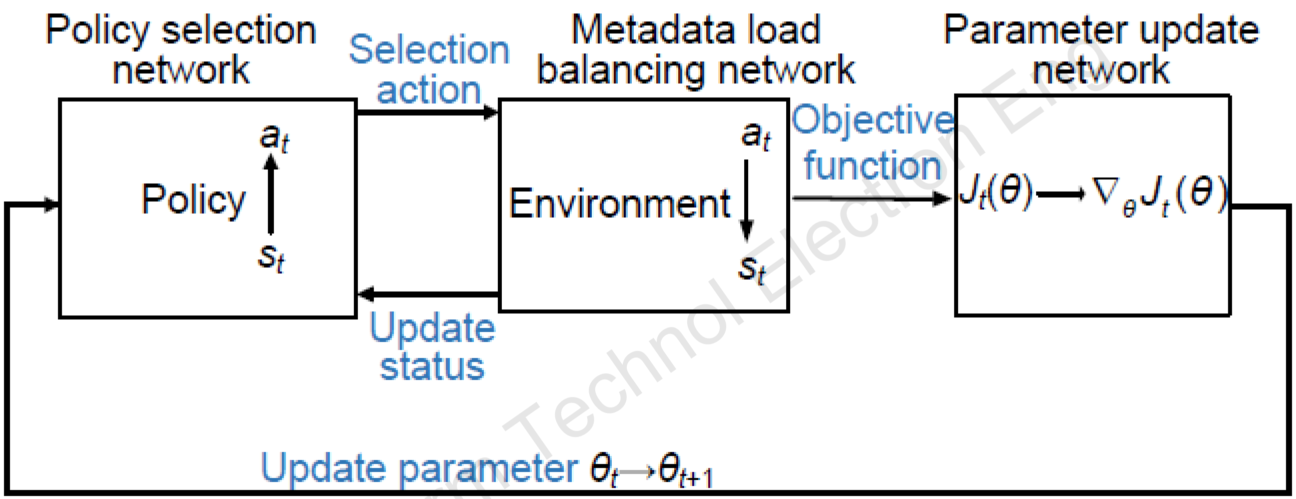

Fig. 4 Metadata dynamic load balancing mechanism model

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Major results

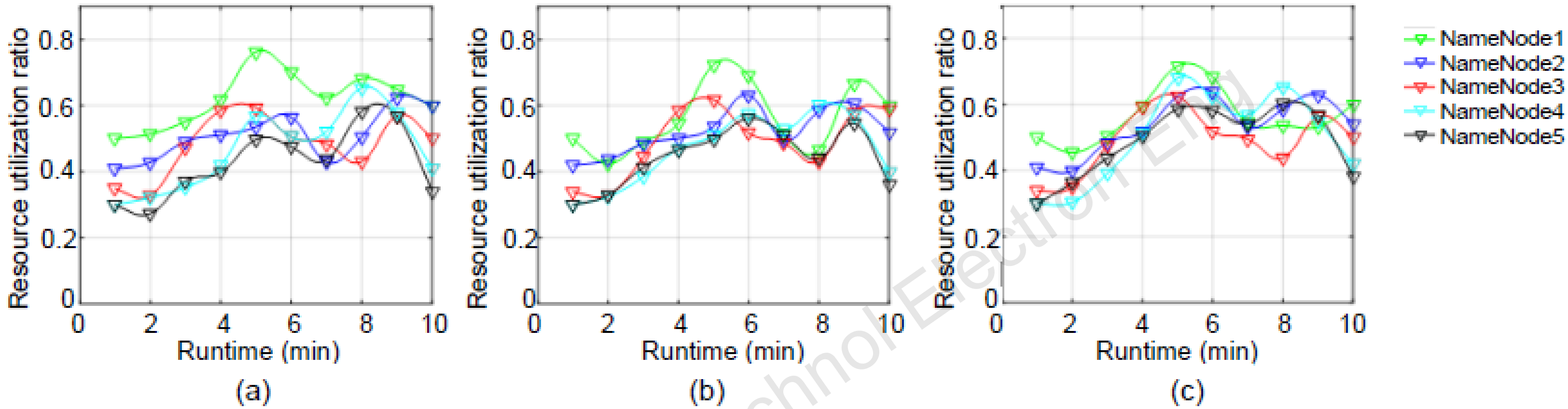

Fig. 5 Resource utilization ratios of each NameNode under different algorithms: (a) HDFS Federation; (b) BBLA; (c) MDLB

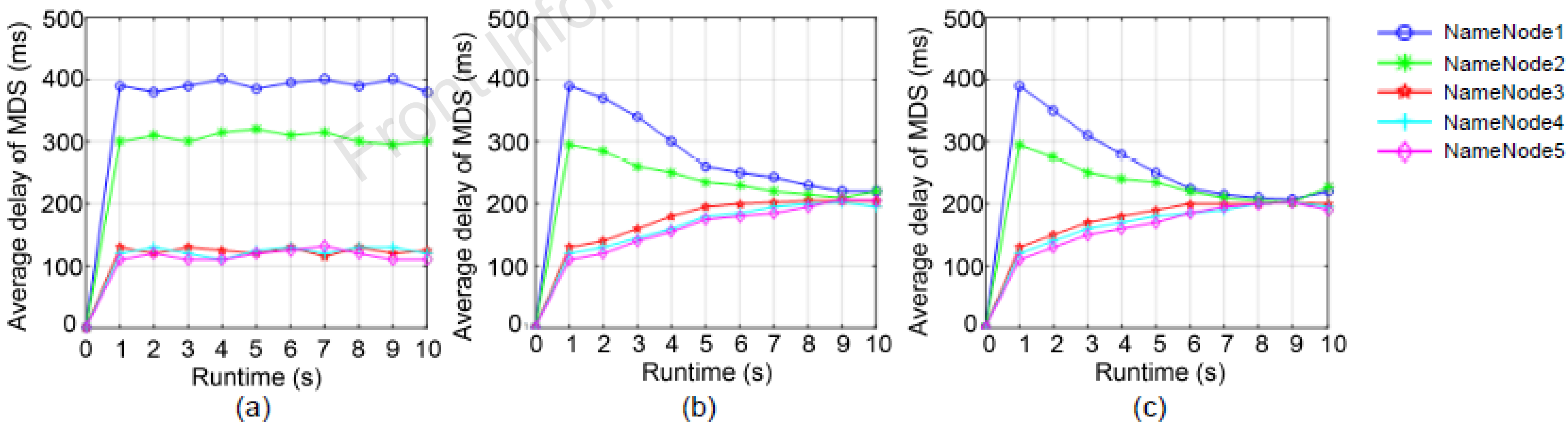

Fig. 6 Time-varying curves of the metadata delay time: (a) BBLA; (b) ADMLB; (c) MDLB

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Major results (Cont'd)

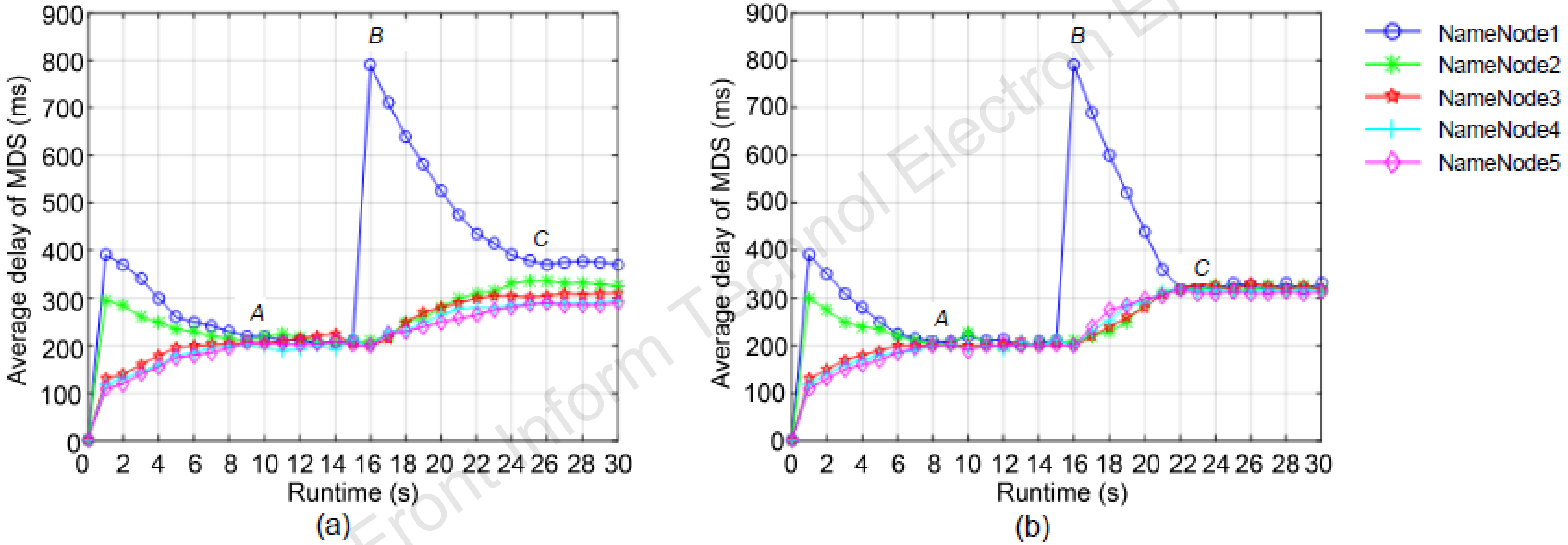

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Fig. 7 Time-varying curves of the metadata delay time in systems with a large amount of data: (a) ADMLB; (b) MDLB

Conclusions

- CPU computing performance, memory performance, I/O performance, and disk size make us fully consider the multiple indicators in the distance function, making the results comprehensive and accurate.
- We reduce the deficiencies of existing hashing-based load balancing algorithms, so that the improved distributed storage cluster can dynamically adjust load based on the current MDS state.
- When dealing with a surge of access to a certain MDS node, the entire system can respond quickly, reasonably re-allocate the metadata, and reach the load balancing state again by the MDLB algorithm.
- We introduce the RL method into load balancing strategy design. Using the indicator of reward, the selection of parameters in the framework is reasonable, and the metadata is justifiably distributed to the MDS.

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