2019 IEEE International Conference on Consumer Electronics
- Taiwan (ICCE-TW)

A High-availability Data Backup Strategy for IPFS

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***Abstract*—The InterPlanetary File System (IPFS) is a peer-to-peer distributed file system. It can greatly reduce the cost of data storage and improve the performance of data download. Currently, the IPFS-based distributed storage systems mostly uses the centralized backup mechanism. Although it can provide high data availability, centralized nodes will be single fault peer and become the bottleneck of system performance. This paper proposes a high-availability data backup strategy based on QoS and interest of IPFS nodes. Compared with the existing methods, the experimental results demonstrate that our proposed strategy is more effective and practical.**

瓶颈

I. Introduction

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IPFS [1] is a distributed storage and transmission protocol for content addressable, versioned, peer-to-peer hypermedia. The nodes in the IPFS network are free and can go online or offline at any time. After the node goes offline, the data uploaded by this node will become inaccessible without being backed up by other nodes. To ensure the high availability of file, most of the current applications that use IPFS as the underlying storage generally provide official storage nodes to back up user files. However, this method violates the original intention of IPFS, and the backup node becomes the bottleneck affects the system performance. A redundancy scheme [2] based on stored code can minimize the storage and network costs of P2P systems by the simple replication. However, it is not suitable for IPFS as the storage structure of IPFS is Merkel Forest. The system proposed in [3] integrated social networks into the P2P network for efficient and trustworthy file sharing. In this paper, we consider both QoS of the node and the degree of interest of the node to the file to select the file backup node, and push the file to the backup node while the file is uploaded. Hence, the algorithm ensures the efficient availability of data in IPFS network when we consider the node satisfaction, network search performance, and redundancy.

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II. System Model

IPFS is a P2P network, which is represented by $G = (V, E)$ where V is the set of all IPFS nodes and E denotes the edges of the two nodes. $d(i, j)$gives the ID exclusive OR(XOR) distance between nodes i,j. For node i, we define the availability of the node as an online probability.

$$P_i = \frac{\text{online time}}{\text{online time} + \text{offline time}} \tag{1}$$

Each node has limited storage space and the node space availability is as C_i.

$$C_i = 1 - \frac{\text{Used disk space}}{\text{Reserved disk space}} \tag{2}$$

构成

IPFS networks are addressed based on node distance. For node i, all nodes j of $d(i, j) < D$ constitute its neighboring node set N_i.Then, the neighboring subgraph $G_1 = (V, E_1)$of G is obtained, where $e(i, j) \in E_1|d(i, j) < D$. The weight $\omega_1(i, j) = \alpha/d(i, j)(\omega_1 \leq 1)$ is defined for the edge $e(i, j) \in E_1$. Based on the attention representation between the nodes, for the node i, all the interested nodes i constitute its interest node set I_i, then the interest subgraph $G_2 = (V, E_2)$ of G is obtained, where $e(i, j) \in E_2|j$ follows i . We define weight $\omega_2(i, j) = 1$ for the edge $e(i, j) \in E_2$. For $e(i, j) \in E$, $e(i, j) = \omega_1(i, j) + \omega_2(i, j)$.

The backup node's selection goal is to select the least backup node, minimize the traffic overhead, and make the file availability meet the predetermined requirement $P*$. Assume that the backup node set is K and $C*$ is the minimum storage remaining capacity of the node that is preset Defining the performance of node i for file backup, donated by F_i . The objective is to maximize backup performance F_i with constraints (5) and (6).

$$F_i = \frac{\sum_{j \in K} P_j \times e(i, j)}{|K|} \tag{3}$$

$$\text{Max} \frac{\sum_{j \in K} P_j \times e(i, j)}{|K|} \tag{4}$$

$$\text{subject to} \quad P_i \geq P* \tag{5}$$

$$C_j \geq C*, \forall j \in K \tag{6}$$

III. The Proposed Backup Algorithm

For node i, proposed algorithm for finding the backup node is as follows: The performance of the backup F_i depends on the number of P_j, $e(i, j)$ and redundancy. First, the product of the pre-selected nodes P_j and $e(i, j)$ is calculated, and the largest node is sequentially selected to join the target set. Filter the target collection by restricting conditions. Therefore, the K that satisfies the condition first is the optimal K. The process of finding K is as follows:

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Algorithm 1 The process of finding optimal set K

Input: $N_i \cup I_i$: interest set and proximity set of node i; P_j: online probability of node j; C_j: space availability of node j; $P*$: predetermined available probability; $C*$: minimum space availability of each node ;

Output: optimal K

initial$\{q_j\} = \emptyset$;
Calculate the product of P_j and $e(i,j)$ of all nodes j connected to node i,and add results to $\{q_j\}$;
Delete the node of $C_j < C* \in \{q_j\}$
repeat
    Find the maximum value q_{max} in $\{q_j\}$, join the target set K, and calculate P.;
    delete q_{max} in $\{q_j\}$;
until $P \geq P* \parallel \{q_j\} = \emptyset$

If the K that satisfies the condition is not found in the above traversal, the file access degree uploaded by the node is extremely low, and the file can be backed up to $N_i \cup I_i$ in consideration of system performance.

IV. EXPERIMENT

A. Comparison of distributed and centralized backup strategy

An IPFS system with 50 nodes is constructed using MATLAB simulation. The compared methods contain centralized and distributed backup mechanism. In our experiment, the average access time of nodes is calculated by varying their number, and the bandwidth and transmission rate remain unchanged.

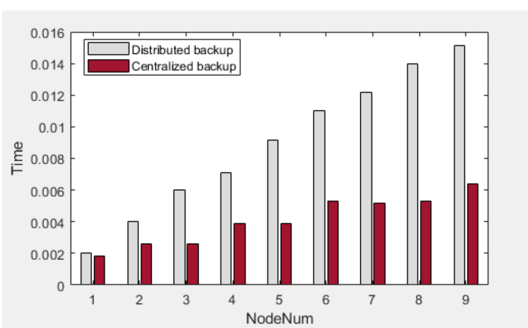

Fig. 1: result of experiment A

As shown in Figure 1, when the bandwidth and transmission rate are equal, the access time of the centralized backup strategy increases linearly with the number of access nodes. Through the data of the distributed backup strategy, it can be seen that when the number of nodes grows, the access time of the distributed backup also shows an increasing trend, but it is slow. This is because different files have different backup nodes in the network to provide services. Additionally, it can also be seen from the figure that when the number of nodes is relatively large, the access time of the distributed backup is much smaller than that of the centralized backup.

B. Comparison of multi-factor and single-factor distributed backup strategy

IPFS network has a neighbor relationship, and we will use the proximity relationship backup and the proximity interest relationship backup to compare the backup performance. Single-factor strategy is proximity backup. Multi-factor strategy is interest and proximity backup. The IPFS system with 20 nodes is constructed by MATLAB simulation. Under the condition that the parameters of the nodes are the same, when uploading files to one node, the files are processed according to the neighboring node backup and the interest neighboring backup. We compare the redundancy and backup performance.

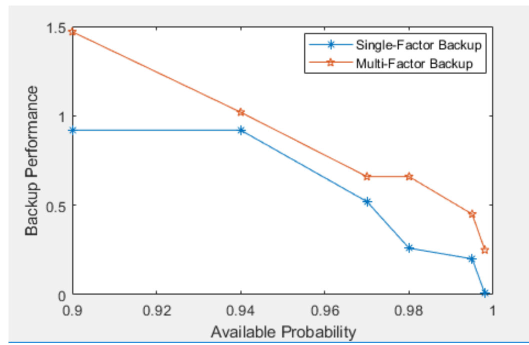

Fig. 2: result of experiment B

The redundancy of two strategys is basically the same because it is mainly determined by the distribution of node available probability. It can be seen from Figure 2 that the backup performance of the interest proximity is always higher than that of the proximity. Interest proximity backup considers the node, search rate and storage willingness. Although the redundancy is roughly the same, the storage is in the proximity of the interest proximity backup which can improve the satisfaction of the backup node greatly.

V. CONCLUSION

This paper proposes a distributed backup strategy based on QoS and intesests of IPFS nodes. This strategy optimizes file backup performance by selecting the appropriate backup node among the interest and proximity nodes. The problem of limited storage capacity and low parallel access performance for centralized backups can addressed via the proposed strategy. Experiments prove the feasibility and efficiency of our strategy.

ACKNOWLEDGMENT

This work is partly supported by the National Natural Science Foundation of China under Grant 61772085, 61672109 and 61877005.

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