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DARS: A dynamic adaptive replica strategy under high load Cloud-P2P

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HIGHLIGHTS

- The paper presents a dynamic adaptive replica strategy under high load Cloud-P2P.
- The strategy obtains the replica creation opportune moment based on the node's overheating similarity.
- The strategy applies the fuzzy clustering analysis method to find optimal placement node.
- The node creates replicas by a decentralized self-adaptive manner.
- The strategy has been simulated and evaluated to demonstrate its effectiveness.

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ABSTRACT

In Cloud-P2P system, replica strategy is utilized for obtaining low access delay and high load balance, which requires paying more attention to the time of replica creation. Most of current replica strategies usually utilize the method of afterwards adjustment fixed threshold. However, these strategies may increase a large number of overload nodes and then lead to aggregate effect of being overloaded, especially under high load condition. To deal with the problem, this paper proposes a Dynamic Adaptive Replica Strategy (DARS) based on the node's overheating similarity. DARS addresses the problem of replica creation time, including obtaining the replica creation opportune moment and finding the optimal replica placement node, by a decentralized self-adaptive manner. Based on the overheating similarity, DARS applies fuzzy membership function to obtain the replica creation opportune moment, which enables the node to create replica before its overload. Meanwhile, DARS adopts the fuzzy clustering analysis method to find out the node with high node degree and low load which is used as optimal placement node to store replicas. Extensive experiments demonstrate that DARS obtains superior performances in access latency around 15%∼20% on average and better load balance than other similar methods under high load condition.

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1. Introduction

Cloud storage is a new extension of cloud computing, providing data storage and transaction access service [1,2]. With the proliferation of cloud storage, as an intentional supplement, the P2P technology has been applied in cloud storage [3–10]. This new framework is called Cloud-P2P by a lot of scholars. The Cloud-P2P has attracted much attention, and has been used in many applications, e.g., IPTV [4], Video-on-Demand [11], etc.

In Cloud-P2P system, overloaded conditions are common during flash crowds. If a node receives many requests at a time, it can become overload and consequently cannot respond to the requests quickly, leading to the node overheating. Replica strategy is an effective method to deal with the problem of node overload by distributing load over replica nodes [12], which helps to achieve lower access delay and better load balance by reducing node response latency and accessing pressure [12,13]. Since the highly popular files could exhaust the bandwidth capacity of the node, leading to the service node overload. In order to reduce the access pressure of node, replica strategy can create replicas for these popular files, and store them on the specified nodes.

Nowadays, numerous replica strategies have been proposed [12–20]. A lot of researches show that the replica strategy generally needs to focus on the time of replica creation. The time

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of replica creation is a process, including obtaining the replica creation opportune moment and finding the replica placement node to store replica. The traditional strategies usually utilize method of **afterwards adjustment fixed threshold** to deal with this process. These strategies usually preset a fixed threshold which are based on a certain performance (e.g., bandwidth [13], node load [12], etc.). When the node reaches predefined conditions, a particular file stored on the node creates a replica and stores the replica to other node, which can reduce the node access pressure or release rate of bandwidth occupancy. Therefore, these strategies achieve low access delay and high load balance.

However, under high load condition, these traditional strategies, which still utilize the idea of traditional fixed threshold, may cause the following risks. First, they may lead to overload nodes increasing. In order to reduce the access pressure, these methods begin to create replica when the node reaches or exceeds the predefined threshold. But at this point, the node has been an overload node, which definitively increases the number of overload nodes. Consequently, the problem of obtaining the replica creation opportune moment is very important. Second, these strategies may cause **aggregate effect of being overloaded**. The node needs to create a replica and store the replica to other node to release its access pressure when it overloads. But under high load condition, most of nodes face the risk of overload at any time. In such an extreme case: the placement node is also about to reach the predefined threshold. It may overload when a replica is stored on it, leading to aggregate effect of being overloaded. Consequently, the problem of how to find the optimal node to store the replica also needs to be carefully considered.

To deal with these risks, this paper presents a Dynamic Adaptive Replica Strategy(DARS) based on the **node's overheating similarity**. This paper defines the overheating similarity, which is a probability that a node changes into an overloaded node. DARS realizes the ultimate goal of low access delay and high load balance under high load condition. Specifically, it has the following novel features to overcome the drawback of the traditional methods.

One novel feature of DARS is that it achieves the goal of reducing the number of overload nodes and relieving the aggregate effect of being overloaded under the high load condition. In order to achieve the goal, DARS focuses on the replica creation opportune moment and the selection of placement node. Based on the overheating similarity, it applies fuzzy membership function to obtain the opportune moment. DARS defines the membership function of overheating similarity according to node load, which designs a similarity range for relieving node overload. The similarity range is a probability range that a node changes into an overload node. When the node's overheating similarity reaches or exceeds the similarity range, it begins to create replica. In other words, before the node overload, it begins to create replica. In order to find optimal node, DARS combines the overheating similarity with the node degree as reference index, and uses the fuzzy clustering analysis method to select the node with high node degree and low overheating similarity as placement node, which can effectively decrease the probability of the placement node overload.

Another novel feature of DARS is that it conducts the operations in a decentralized self-adaptive manner without compromising access delay. Although the data center of Cloud-P2P can periodically monitors the files on the nodes, a centralized fashion cannot handle overload in time, especially under high load condition. Rather than depending on such a centralized method, DARS enables nodes themselves to decide whether to create or store replicas based on their load, which can effectively reduce risk of overload. The self-adaptive manner can handle overload in time and reduces the access delay, enhancing DARS scalability. Meanwhile, the manner relieves the data center burden.

The rest of the paper is structured as follows: Section 2 presents the related works. Section 3 presents DARS replica strategy with theoretical analysis. In Section 4, extensive experiments show that DARS obtains better performances than similar approaches within a variety of metrics, and analyzes of various factors are conducted. Finally, conclusion is summarized in Section 5.

2. Related work

The replica strategy become a hot research topic for many years, and has been widely used in many applications, e.g., P2P Network [21–23], Cloud storage [1,2,20,24], large data storage [25,26], the system of disaster recovery [14], fault tolerant technique [27,28], Data Grid [15] and distributed system [29], etc.

Nowadays, a large number of replica strategies have been proposed. Different replica strategies have different evaluation criterions, e.g., session state of data block [30], access frequency of replica [12,13], the security of data [17,27], etc.

In general, the replica strategies can be divided into static strategy and dynamic strategy. In static strategy, the number of replicas is fixed (e.g., GFS [31,32] and HDFS [25]). This strategy is so easy, and manages conveniently, but lacks flexibility. At present, most of the research focus on the dynamic strategy [12,13,15–20,30,33]. The number of replicas is variable in these strategies, and can be dynamically adjusted according to the requirements of the request. The way of replica placement is usually the random placement and order placement. Based on the system operation condition, these strategies store the replica on the query path by random way or order way when a node creates a new replica.

Paper [12] proposes an efficient and adaptive decentralized file replication algorithm(EAD). EAD selects the query traffic hubs and frequent requesters of a file as its replica nodes to guarantee hit rate while the minimum number of replicas. In EAD, base on request number of file, when the node's request number achieves node's access threshold of pre-set, the node begins to create new replica.

Paper [16] constructs a reliability model of replica service for cloud storage system. The model presents the method of data service reliability, trigger of replica creation and the storage node section according to the relationships among access reliability. This paper aims to the reliability of data service and the number of redundant replicas further decrease.

Paper [18] presents a file replication mechanism SWARM based on swarm intelligence. SWARM determines the placement of a file replica based on the accumulated query rates of nodes in a swarm. The nodes in a swarm, achieving fewer replicas and high querying efficiency, share replicas.

Paper [19] proposes the Selective Data replication mechanism in Distributed Data centers (SD^3). SD^3 aims to reduce inter-data center communications while still achieving low service latency. It considers update rates and visit rates to select user data for replication. Furthermore, SD^3 atomizes users' different types of data for replication, ensuring that a replica always reduces inter-data center communication.

There are other studies for file replication in the Cloud-P2P [4,5,7–11]. These works study the system performance such as successful queries and bandwidth consumption, focus on the node or file achieving a predefined condition. However, these works pay less attention to the problem that the node may have been overloaded when node or file achieves the predefined condition.

3. DARS replica strategy

In this section, we describe the various aspects of the DARS replica strategy in detail. We present DARS from the following aspects:

1. The relationship between the node load and the node state is discussed (Section 3.1).

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