

Chapter 65

An Efficient Data Replication Algorithm for Distributed Systems

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ABSTRACT

This article describes how data replication plays an important role in distributed systems. It primarily focuses on the redundancy of data at two or more nodes, to achieve both fault tolerance and improved performance. Therefore, many researchers have proposed various data replication algorithms to manage the redundancy of data. However, they have not considered the faults that are associated with the nodes, such as permanent, transient and intermittent. Moreover, they have not incorporated any recovery approach to rejoin the failed nodes. Therefore, the authors propose a data replication algorithm, called dynamic vote-based data replication (DVDR). The main contribution of DVDR is to consider all types of faults and rejoin the failed nodes. DVDR is based on dynamic vote assignment among the connected nodes, and referred as passive and non-hierarchical one. The authors perform rigorous analysis of DVDR and compare with an existing dynamic vote assignment algorithm. The result shows the efficacy of the proposed algorithm.

INTRODUCTION

In distributed systems, data replication is the process of storing multiple copies of data at different nodes (Tenzekhti, Day, & Ould-Khaoua, 2002; Wang, & Li, 2006). The primary objective of data replication is to increase the availability of data and fault tolerance. Moreover, if one of the nodes is failed due to some unavoidable reasons, then the data is accessed from other nodes. However, the major concern is to make the data consistent in each individual node (Jajodia, & Mutchler, 1990). In general, replication

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is of two types, namely active and passive. A replication is said to be active if the update request is processed at every node. It can be used for deterministic processes. On the other hand, passive replication processes an update request on a single node and propagates the update to the other nodes. It can be used for deterministic and nondeterministic processes (Deshpande, & Kamalapur, 2014).

In distributed systems, a fault (or a failure) can disconnect the connected nodes (referred as a network) into two or more disconnected networks. A fault may be permanent, transient and intermittent (Koren, & Krishna, 2007; Panda, Khilar, & Mohapatra, 2013; Panda, Khilar, & Mohapatra, 2014; Mishra, & Panda, 2017; Panda, & Khilar, 2012; Panda, & Khilar, 2012; Bhoi, Panda, & Khilar, 2012). A permanent fault at a node reflects severe damage and disconnects the node from the network. A transient fault at a node occurs for a short duration of time. It disconnects the node from the network for some time. An intermittent fault at a node oscillates between active and inactive state. Here, active means presence of the fault, which disconnects the node. On the other hand, passive means that the node works normally. In the presence of the above faults, a network must ensure that the data at each node should be consistent (Koren, & Krishna, 2007).

There are several approaches to manage the multiple copies of data at different nodes. One of them is voting among the multiple copies. This approach can be hierarchical or non-hierarchical. In hierarchical voting, the nodes are represented in the form of a tree. Here, a read operation is carried out by reading any one of the copies and a write operation is carried by updating each and individual copy. On the other hand, the non-hierarchical voting depends on the availability of connected nodes and the node itself. Here, it is assumed that each individual node has exactly one vote.

In this paper, the following data replication problem in distributed systems is presented. Consider an interconnection network in which each node has certain properties such as version number and sites cardinality. The objective is to propagate the message communications among the nodes such that the data at each node should be consistent. Therefore, various studies (Long, 1988; Jajodia, & Mutchler, 1990; Chang, & Yuan, 2000; Chen, Wang, & Chu, 2000; Tenzekhti, Day, & Ould-Khaoua, 2002; Latif-Shangahi, & Hirst, 2005; Wang, & Li, 2006; Deris, Abawajy, & Mamat, 2008; Balasubramanian, & Maskell, 2015; Balasubramanian, Prasad, & Mastorakis, 2016; Warhade, Dahiwal, & Raghuvanshi, 2016; Nagarajan, & Mohamed, 2017) have been made to propagate such message communications. However, they have not considered the faults that are associated with the nodes. Furthermore, they have not incorporated any recovery approach to rejoin the failed nodes. As a result, we propose here a new data replication algorithm, called dynamic vote-based data replication (DVDR) algorithm. The proposed algorithm is based on dynamic vote assignment among the connected nodes and referred as passive and non-hierarchical one. It also incorporates all types of faults, namely permanent, transient and intermittent, and rejoins the failed nodes. We perform extensive analysis on the proposed algorithm DVDR and compare with a well-known existing dynamic vote assignment algorithm. The comparison result between proposed and existing algorithm shows the improved performance of the proposed algorithm in terms of number of failed updates.

Our major contributions are summarized as follows.

- We develop a data replication algorithm for distributed systems. The algorithm is referred as passive and non-hierarchical one.
- We incorporate various types of faults, namely permanent, transient and intermittent, to make the algorithm realistic one.
- We consider rejoin of the failed nodes to incorporate dynamic scenario of the network.

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