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The consensus problem with dual failure nodes in a cloud computing environment

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ABSTRACT

Network bandwidth and hardware technology are developing rapidly, resulting in the rapid development of the Internet. An important component of this development, cloud computing, uses low-power hosts to achieve high reliability. Specifically, cloud computing increases the number of user applications on the Internet. In this context, research should focus on how distributed systems can provide additional reliability and fluency. Notably, the consensus problem is a fundamental concern to fault-tolerant distributed systems. However, previous studies of the consensus problem do not address cloud computing and so they are not suitable within a cloud computing context. To enhance the relevant literature with regard to fault-tolerance, the consensus problem in a cloud computing environment is revisited in this study. The *Dual Fault Protocol* for cloud computing (DFP) that we proposed can solve the consensus problem with a minimal number of rounds of message exchange and tolerates a maximal number of allowable dual failure nodes. The DFP attempts to solve the consensus problem and allows all correct nodes in the topology of cloud computing environment to achieve stable results without any influence from faulty components.

1. Introduction

Today, network bandwidth and hardware technology must advance on pace with the vigorous development of the Internet. Notably, the concept of cloud computing allows for more applications for internet users and, in the context of real world of technology, a distributed system must provide adequate reliability and fluency [1,9]. In a cloud computing environment, achieving perfect reliability must be accomplished by allowing a given set of nodes to reach a common agreement even in the presence of faulty nodes.

1.1. Background

Cloud computing is an important concept in today's distributed systems. It is used chiefly for business applications in which computers cooperate to perform a specific service. In addition, internet applications are continuously being enhanced as regards multimedia and the rapid development of relevant devices occurs quickly within the network system [1,3]. As network bandwidth and quality outstrip computer performance, various communication and computing technologies

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previously regarded as being specified for different domains can now be integrated, such as: telecommunication, multimedia, information technology and construction simulation. Thus, applications associated with network integration have gradually attracted considerable attention. Similarly, cloud computing facilitated through distributed applications over networks has also gained increased recognition. In a cloud computing environment, users have access to faster operational capability on the Internet and, crucially, these computer systems require high levels of stability to keep pace with this level of activity [1].

In a distributed computing system, nodes allocated to different places or in separate units are connected so that they may collectively be used to a greater advantage [9]. In the computer system, each node must pass messages to other nodes to cooperatively complete user requests. Thus, the tasks in a distributed system must be synchronously completed and the nodes must reach common agreement. Notably, cloud computing can ensure an increased ability to use low-power nodes to achieve high reliability. In addition, cloud computing has greatly encouraged distributed system design and applications to support user-oriented service applications [9]. Furthermore, many applications of cloud computing are able to increase convenience to users; YouTube provides us with an excellent example of this [9]. Node reliability is one of the most important aspects of cloud computing as it ensures overall reliability and fluency. As such, a mechanism to ensure that a set of nodes reaches an agreed value is necessary [4].

1.2. The consensus problem

In the cloud computing environment, many users seek to execute application services simultaneously. Therefore, the high fault-tolerance capability of a cloud computing environment must be respected. However, the symptoms of a faulty node can influence the normal operation of a system. Cloud computing in distributed systems must tolerate the faulty nodes in the service environment because the system should be able to respond to user requests quickly and completely. Specifically, cloud computing entails using many computers in conjunction to complete a specific service for users. The requisite large number of computers will necessarily introduce faulty components into the system. However, the system must allow for the tolerance of faults while maintaining functionality. Simultaneously, in the cloud computing environment, nodes which receive user requests may be influenced by a faulty node; hence, the affect of faulty nodes must be mitigated. The *Byzantine Agreement* (BA) problem has been studied extensively in the literature and the consensus problem is a closely related subproblem of the BA problem [4,11]. Notably, the BA problem was first introduced in 1982 by Lamport who proposed a protocol with which to solve the fault tolerance problem in computer systems [4].

The consensus problem is one of the most important issues regarding the design of a fault-tolerant distributed system [5]. Through solving the consensus problem, many applications can be more easily realized [12]. Specifically, this paper is concerned with the solution to the consensus problem in a cloud computing environment which can allow users to execute applications. The problem can by defined through ensuring that the correct nodes in an n nodes distributed system reach consensus agreement. Here, each node chooses an initial value and communicates with other nodes by exchanging messages. The consensus problem in a cloud computing environment is revisited to discuss its solution with dual failure nodes in a given network topology. The proposed protocol is referred to as the *Dual Fault Protocol* for cloud computing (DFP) and can lead to a consensus between each correct node in a cloud computing environment.

The remainder of this paper is organized as follows: Section 2 discusses the related works; the concept of DFP is outlined in Section 3; examples are given in Section 4; Section 5 describes the correctness and complexity of the DFP; and Section 6 offers our conclusions.

2. Related work

In the previous literature, the consensus problem has been solved within various network topologies. However, previous studies of the consensus problem do not specifically address cloud computing in the context of internet applications [12]. As such, in this paper, the topology of a cloud computing environment is applied. Subsequently, the consensus problem with dual failure nodes in the topology of a cloud computing is discussed.

2.1. Cloud computing

Cloud computing is a distributed system concept that has been implemented by businesses such as Google and Amazon [13]. Specifically, Google provides various applications on their internet platform such as Gmail and YouTube [17]. In addition, Google provides free storage capacity for each user and the large and powerful Google search engine allows users to find multiple results from different file types on the Internet.

Amazon provides many applications through *Amazon Web Services* (AWS) in a cloud computing environment; for example, *Elastic Compute Cloud* (EC2), *Simple Storage Service* (S3), and *CloudFront* (beta version) [13,14]. With AWS, users can requisition computing power, storage and other services and gain access to a suite of elastic IT infrastructure services on demand. The AWS allows users to rent the infrastructure or application services platform in a cloud computing environment on a cost-basis.