A Preliminary Study of Suppressing Redundant Nested Invocations from a Web Service with Active Replication

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ABSTRACT

Zwass (1996) suggested that middleware and message service is one of the five fundamental technologies used to realize electronic commerce (EC). The Simple Object Access Protocol (SOAP) is recognized as a more promising middleware for EC applications among other leading candidates such as CORBA. We notice that the fault-tolerance issue is somewhat neglected in the current standard, that is, SOAP 1.1. We therefore proposed a fault tolerant Web service called fault-tolerant SOAP or FT-SOAP through which Web services can be built with higher resilience to failure. Active replication is a common approach to building highly available and reliable distributed software applications. The redundant nested invocation (RNI) problem arises when servers in a replicated group issue nested invocations to other server groups in response to a client invocation. In this work, we propose a mechanism to perform auto-suppression of redundant nested invocation in an active replication FT-SOAP system. Our approach ensures the portability requirement of a middleware, especially for FT-SOAP. The current design of the suppression mechanism itself does not consider the fault-tolerance issue. In other words, it suffers from the single-point of failure. Furthermore, the preliminary performance results indicates significant performance penalty due to inefficient SOAP invocations. More comprehensive experiments are needed to further investigate the feasibility of the current approach in the context of system performance.

Keywords: active replication; fault-tolerance; multithreading; Web service.
INTRODUCTION

With the advance of computer and communications technology, distributed computing systems have become increasingly popular in recent years. Many of these distributed systems are designed to perform critical tasks in a hazardous environment (Apache, 2003). Active replication techniques are commonly used to build critical software systems to ensure their reliability and availability (Microsoft, 2002). Modern large-scale distributed applications are usually built on distributed middleware to cope with design issues such as heterogeneity, scalability, and portability (Brown & Kindel, 1996). OMG’s CORBA (OMG, 2001) and recent developed SOAP (W3C, 2000) are such middlewares. OMG recently announced a specification called fault-tolerant CORBA (OMG, 1998) that recognizes the importance of fault tolerance. One of the open issues that OMG pointed out in its RFP of fault-tolerant CORBA is the redundant nested invocations (RNI) problem (OMG, 1998).

A nested invocation refers to an invocation on a server $B$, from another server $A$, upon an invocation on $A$. The RNI problem arises when a group is serving a client invocation and replicas in this active replication group all make the same (redundant) nested invocations to another server. An example is used in Figure 1 to illustrate the RNI problem in more detail. Figure 1 shows an active replication group $A$ that is configured with two active replicas $A_1$ and $A_2$. Suppose that an invocation $A$->do() arrives at group $A$. This invocation later triggers two nested invocations, namely, $V$->addV(2) and $U$->addU(1) shown in Figure 1, on each server $U$ and $V$. Server $V$ will receive two identical invocations, one each from $A_1$ and $A_2$. Because they are identical in $A$, it is clear that these two nested invocations are redundant to server $V$. Similarly, server $U$ will face the same problem. Redundant invocations could cause inconsistent states, particularly if such requests lead to state changes. OMG’s RFP of fault-tolerant CORBA (OMG, 1998) advocated the installation of a suppression mechanism for redundant nested invocation (SM) on active replication groups, as shown in the dotted box in Figure 2. The purpose of SM is to ensure that only one of the redundant nested invocations is allowed to be forwarded to the server. In other words, this mechanism identifies all redundant nested invocations first, and then suppresses all of them but one. Figure 2 depicts an effective SM where $V$->addV(2) from $A_1$ is suppressed, since its equivalent RNI from $A_j$ has been sent to server $V$ earlier. By the same token, the nested invocation $V$->addV(1) from $A_1$ is suppressed. Furthermore, this mechanism should deliver invocation results to every member in the replicated group.

Suppose that a server serves one invocation at a time. All servers are implemented as a single thread, and the execution of each replicated server is deterministic. It is readily seen that all nested invocation sequences from replicated servers

Figure 1: RNI Problem

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