Available online at www.sciencedirect.com
ScienceDirect
Decision Support Systems 42 (2006) 1959–1973
Decision Support Systems
www.elsevier.com/locate/dss

An adaptive coordination framework for fast atomic multi-business transactions using web services

Jonghun Park [a,*], Ki-Seok Choi [b]

[a] Department of Industrial Engineering, Seoul National University, San 56-1, Silim-Dong, Kwanak-Gu, Seoul 151-742, South Korea
[b] Hankuk University of Foreign Studies, South Korea

Received 26 March 2005; received in revised form 9 May 2006; accepted 14 May 2006
Available online 21 June 2006

Abstract

Web services are emerging as an effective means for carrying out automated transactions between multiple business parties. While there are several specific protocols that have been discussed to address the problem of coordinating web services-enabled business transactions, we consider the tentative hold protocol (THP) that allows the placement of tentative holds on business resources prior to actual transactions in order to provide increased flexibility in coordination. In this paper, we present a formal coordination framework for applying THP in conjunction with two phase commit protocol to the problem in which service providers independently manage resources and clients seek to acquire the resources from multiple providers as a single atomic transaction. The proposed framework facilitates the performance optimization of THP through effective parameterization with the notion of overhold size and hold duration. Subsequently, a detailed analysis is carried out to obtain an efficient method that can optimize the performance by adaptively determining the hold duration. The simulation results show that the proposed adaptive approach yields a significant improvement over other non-adaptive policies.

Keywords: Web services; Business transactions; Tentative hold protocol; Two phase commit protocol; Distributed coordination

1. Introduction

Currently significant efforts are being invested in application integration, enabling business processes of different companies to interact and form complex multi-party processes. In particular, as web services are becoming the predominant technology for facilitating business-to-business (B2B) collaboration, there are increasing needs for the enhanced transaction models that can effectively support complex, multi-party business interactions based on web services. Although efficient and reliable, the traditional transaction models that require fine-grained control of locking and close trust are not directly applicable for open, loosely coupled computing environments consisting of autonomous and heterogenous services [21]. In a web service based B2B environment, transactions are often complex, involve multiple autonomous parties, span many independent organizations, and may have long duration [17].

There are a number of emerging specifications that seek to address the requirements of such web service based collaborative business transactions. These specifications define a flexible and extensible framework for

* Corresponding author. Tel.: +82 2 880 7174; fax: +82 2 889 8560.
E-mail addresses: jonghun@ieee.org (J. Park), kchoi@hufs.ac.kr (K.-S. Choi).

0167-9236/$ - see front matter © 2006 Elsevier B.V. All rights reserved.
doi:10.1016/j.dss.2006.05.004

the coordination of loosely-coupled web services by use of a predefined set of transaction semantics, and they also suggest new notions of transactions that relax some of the ACID properties [1] of conventional transaction processing [6].

Business Transaction Protocol (BTP) [15], a committee specification of the Organization for the Advancement of Structured Information Standards (OASIS), is proposed to support interactions that cross application and administrative boundaries, requiring extended transactional support beyond the ACID properties. It is based on two phase commit (2PC) [1] for short duration interactions called atoms, which can be further aggregated into larger non-ACID transactions called cohesions [12]. More recently, Web Services Transaction (WS-Transaction) proposed by IBM and Microsoft [4] provides specifications for atomic transactions in a trusted domain that uses 2PC, and for business activities using compensating transactions. It also defines an XML-based protocol for multiple transaction processing platforms to interoperate.

Taking a slightly different approach to the problem, Tentative Hold Protocol (THP) [19], published as a W3C (World Wide Web Consortium) note, attempts to define a building block that can work with other technologies in order to facilitate the automated coordination of multi-business interactions as well as the creation of new opportunities to leverage the web services to improve business efficiencies. THP is an open, loosely coupled, messaging-based framework for the exchange of tentative commitments between businesses prior to actual transaction [19]. It addresses more semantic issues than low-level transactional mechanisms by providing a standard means for trading partners to place tentative holds for business resources.

In this protocol, it is possible that multiple clients can place tentative holds on the same item prior to sale, and whenever one client completes the purchase of the item, the other clients may receive notifications that their holds are not valid any more. Hence, the clients have the ability to request tentative holds on the resources they want to acquire as a single coordinated purchase, verifying availability before completing the transaction. On the other hand, the resource providers may grant non-blocking reservations on their products, retaining control of their resources, while allowing the clients greater flexibility in coordinating their acquisitions.

When combined with existing multi-business transaction coordination methods such as custom applications, compensating transactions, and 2PC, THP can provide several significant benefits. In particular, as claimed in [22], introducing a tentative hold phase to long-running collaborative business applications that employ 2PC protocol for ensuring atomicity of multi-transactions can overcome the limitations of the pure 2PC. THP allows clients to tentatively obtain resources for long time periods before entering the prepare phase of a 2PC transaction, enabling the possibility that the clients make tentative commitments to the terms of a contract and make all decisions without actually requiring the resource provider to lock such resources for the duration. Accordingly, it can shorten the required 2PC lock duration by reducing the time spent on the prepare phase while at the same time it will also facilitate minimizing the time required for business applications to successfully complete their multi-transactions. The result of a simulation study that shows the performance improvement achieved by adding THP to 2PC in a generalized resource allocation environment that allows co-allocation of arbitrary number of resources as well as alternative resource co-allocation schemes can be found in our earlier work [18].

In this paper, we consider the problem in which businesses independently manage and expose their resources through web services and client applications seek to acquire resources from them as a single atomic web service transaction [11]. In such circumstances, the clients are competing for finitely available resources, and it is not guaranteed that the required resources are always available. Moreover, the client should be able to achieve all-or-nothing semantics for the entire end-to-end transaction: if some of the transactions for resource acquisition are not successful, the entire transaction must be canceled. This problem is getting increasing attention in many real-world application contexts [5,9,3], including an e-commerce application that seeks to identify the best combination of many small orders from several businesses for making a purchase [22], a travel web service that interacts with flight, hotel, and car rental services [16], and a supply chain management application that carries out conversational transactions via the web services of suppliers and shippers [7].

Coordination of this kind of multi-business transactions could be carried out through the human intervention or the creation of a custom application that is aware of the inter-dependencies among the transactions. However, the increasing complexity of multi-business interactions driven by the technologies for automated discovery and integration of web services makes it necessary to flexibly automate the coordination in order to increase the business efficiency and agility [20]. Indeed the THP's key contribution is the flexibility it