DSCWeaver: Synchronization-Constraint Aspect Extension to Procedural Process Specification Languages

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ABSTRACT
Correct synchronization among activities is critical in a business process. Current process languages such as BPEL specify the control flow of processes procedurally, which can lead to inflexible and tangled code for managing a crosscutting aspect—synchronization constraints that define permissible sequences of execution for activities. In this article, we present DSCWeaver, a tool that enables a synchronization-aspect extension to procedural languages. It uses DSCL (directed-acyclic-graph synchronization constraint language) to achieve three desirable properties for synchronization modeling: fine granularity, declarative syntax, and validation support. DSCWeaver then automatically generates executable code for synchronization. We demonstrate the advantages of our approach in a service deployment process written in BPEL and evaluate its performance using two metrics: lines of code (LoC) and places to visit (PtV). Evaluation results show that our approach can effectively reduce the development effort of process programmers while providing performance competitive to unwoven BPEL code.

Keywords: modeling languages; petri nets; procedural languages; process model

INTRODUCTION
As more organizations adapt their execution models to become process oriented, it is increasingly important to support process modeling with expressive specification languages. This article focuses on the specification of process synchronization (Schmidt & Assmann, 1998). The recent trends in synchronization modeling have adopted a procedural style in which sequencing constructs (e.g., and-split and and-join) are used to specify the control flow of a process. In languages such as BPEL (business process execution language; Specification:
Business Process Execution Language for Web Services Version 1.1, 2003) and XPDL (extensible markup language [XML] process definition language; Workflow Management Coalition [WMC], 2002), recurring synchronization patterns of different processes are factored out as primitives for specifying the execution order of activities (van der Aalst, ter Hofstede, Kiepuszewski, & Barros, 2003). While this sequencing, construct-based approach is good at specifying well-structured processes from the perspective of a single endpoint, it has difficulties with synchronization needs outside of recurring patterns; for example, activities in distributed parallel subprocesses require synchronization.

This article describes an aspect-oriented programming (AOP) approach to synchronization modeling in which synchronization constraints are declaratively expressed in relationship statements between activities in a process. The goal of this approach is to minimize the dependencies between process-specific functionality and synchronization control. It has been observed that synchronization control described procedurally can lead to tangled and fragile code for both process maintenance and adaptation (Lopes & Lieberherr, 1994; Pesic & van der Aalst, 2006; Singh, 2003). The challenge here is to find appropriate high-level primitives to express various synchronization behaviors that alleviate the synchronization difficulties in procedural languages. Another challenge is to automatically combine the synchronization constraints with other aspects of a process so that the result of applying this method is both compatible with the existing procedural programming environments and suitable for service-oriented environments.

Our method is based on DSCWeaver, a tool that offers a synchronization-aspect extension to procedural languages such as BPEL. The first contribution of DSCWeaver is the DAG (directed acyclic graph) synchronization constraint language (DSCL; Wu, Pu, & Sahai, 2006), which can be used to declaratively specify synchronization constraints for a process. DSCL detangles synchronization code from the base code of a process and provides flexible and expressive primitives to describe synchronization relationships for complex and evolving processes. DSCL draws on synchronization research in parallel programming (Campbell & Habermann, 1974; Salomaa & Yu, 1999), from which we adopt three desirable properties. First, DSCL provides fine granularity control on synchronization constraints. Instead of being regarded as an atomic unit, the life cycle of an activity is a sequence of states. It synchronizes with other activities based on its current states. Second, DSCL has a declarative syntax so that designers only need to specify what to be synchronized instead of how to implement it. As a result, additional synchronization constraints can be incrementally specified. Services invoked by the process can also specify their synchronization constraints declaratively and submit them to the process execution engine. Third, DSCL provides validation support to verify the correct synchronization behavior of processes by translating DSCL into Petri nets (Murata, 1989). Problems such as deadlock and an infinite synchronization sequence in a process can be detected by tools, for example, CPN (colored Petri nets) Tools (Ratzer et al., 2003).

The second contribution of DSCWeaver is the generation of an executable program from the DSCL synchronization constraints and other aspects of a process that correctly implements the original constraints. DSCWeaver translates the constraints into a set of synchronization messages with the ordering information. The code for sending and receiving these messages is inserted at the beginning and the end of each activity. At run time, activities are synchronized by exchanging these messages in order. These synchronization messages are generic and applicable to any process programming language that supports the basic messaging primitives (i.e., send and receive). We believe that messaging is well suited for synchronization control in service-oriented architectures where a process may need to be distributed for performance or implementation reasons (Chafle, Chandra, Mann, & Nanda, 2004; Schmidt &
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