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A view framework for modeling and change validation of artifact-centric inter-organizational business processes

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ABSTRACT

Over the past several years, more efficient approaches have been on increasing demands for designing, modeling, and implementing inter-organizational business processes. In the process collaboration across organizational boundaries, organizations still stay autonomic, which means each organization can freely modify its internal operations to meet its private goals while satisfying the mutual objectives with its partners. Recently, artifact-centric process modeling has been evidenced with higher flexibility in process modeling and execution than traditional activity-centric modeling methods. Although some efforts have been put to exploring how artifact-centric modeling facilitates the collaboration between organizations, the achievement is still far from satisfaction level, particularly in aspects of process modeling and validating. To fill in the gaps, we propose a *view framework* for modeling and validating the changes of inter-organizational business processes. The framework consists of an artifact-centric process meta-model, public view constructing mechanism, and private view and change validating mechanisms, which are specially designed to facilitate the participating organizations to customize their internal operations while ensuring the correctness of the collaborating processes. We also implement a software tool named *Artifact-M* to help organizations to automatically construct a minimal and consistent public view from their processes.

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1. Introduction

Recently, service-oriented architecture (SOA) has become a predominant IT tool for facilitating businesses to meet the changing requirements of the market. SOA particularly enables the business collaboration across organizations by composing Web services to achieve a mutual business goal without comprising the autonomy of participating organizations. The further application of SOA in facilitating business collaboration calls for efficient approaches for designing, modeling and implementing inter-organizational business processes [50]. Recently, work by Desai et al. [20], Ghattas, Montali et al. [63] and [83] shows that the quality of coordinating organizations in a service-oriented collaboration relies on three major requirements, viz., *compliance*, *flexibility*, and *autonomy*. *Compliance* requires all parties must provide the services as they have promised in the collaboration commitment, such as a service level agreement. *Flexibility* allows each party to own the freedom of changing and implementing its own process in the collaboration. Lastly, *autonomy* indicates each participating organization acts independently and is not obliged to reveal its

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own private information (or process) to other parties. Although service choreography defines common collaboration behaviors and keeps the flexibility and autonomy of each participant, actual choreography modeling approaches and related modeling languages mainly describe the collaboration from a procedural perspective, and focus on control-flow, message sequencing, etc., instead of from a data perspective. As such, flexibility and autonomy is still limited by the nature of choreography modeling languages. The work on declarative specification of service choreographies has been proposed by Montali et al. [63], on the basis of DecSerFlow language [84], to overcome such limitations and support dynamic and complex inter-organizational process specifications. Prior to the emergence of service choreography, process view has been adopted to address the flexibility and autonomy issues in business collaborations, and the improvement has been extensively evidenced in work by Van Der Aalst and Basten [81], Liu and Shen [51,52], Schulz and Orlowska [77], Chiu et al. [16,17], Chebbi et al. [14], Eshuis and Grefen [10], Zhao et al. [100,101], Jiang et al. [40] and Eshuis et al. [27]. Originally, a public-to-private view approach has been introduced by [85] and van der Aalst et al., [82] to resolve the privacy and autonomy issues as well as to support change management in dynamic collaboration. Most recently, [83] have proposed a multiparty process-oriented contract to support service choreography based on the concepts of public/private views and accordance along with operating guidelines [61,57]. However, all of above works follow the traditional activity-centric business process modeling paradigm and thereby inherit the limitations in data management, process integration, and process modification, because traditional modeling approaches lack adequate supports of automated tools for business process inter-operation and process schema reuse [38,39].

In the past few years, a new modeling approach has emerged, i.e., *artifact-centric* (operational) business process modeling [68]. Instead of control flows of a business process, business documents and their evolution through a business process become the main modeling objects. This approach depicts a business process in four dimensions, viz., business artifacts, lifecycle of artifact, services, and associations between artifacts and services [34]. The lifecycle of an artifact is defined in terms of "business stages" and the possible evolution of the artifact. The evolution of an artifact and operations of related services are specified in terms of their associations, which can be expressed in a declarative manner, e.g., using ECA rules. As an emerging tool Guard–Stage–Milestone meta-model is becoming a new declarative approach to modeling artifact lifecycle based on a variant of state machines [35,36,21,22,80]. With the efforts of numerous academic researchers and industrial practitioners, artifact-centric modeling approach has been extensively recognized to be with higher level of robustness and flexibility for describing process specification compared to traditional activity-centric approaches. Artifact-centric process modeling receives comprehensive contributions in terms of business transformation practices [6,7,13], foundations [5,59], design methodologies [8,19,56,64,65,73,74,86], model specification, construction, and verification [54,30,31,44,25,29,102,103,21], workflow realization/execution [18,53,66,91,67,88], and monitoring/conformance supports [55,28]. Up to present, artifact-centric approach has been applied to several industry domains such as *healthcare* (e.g., PHILharmonicFlows framework [45,15]), *insurance* (e.g., in [44]), and *finance* (e.g., IBM Global Financing [13]). However, compared with traditional activity-centric approaches, further research is sought after in the area of business collaboration.

By now two main approaches have been proposed for artifact-centric inter-organizational processes. The initial attempt uses artifact-centric interoperation hub to facilitate and support inter-organizational workflows (in an orchestration perspective) among multiple autonomous stakeholders [37]. Recently, this work has been brought forward to an EU-funded project called Artifact-Centric Service Interoperation (ACSI) [3]. It is promised to support a large number of service collaboration by using artifact-centric inter-operations and to achieve dramatic savings over conventional approaches. On the other hand, the artifact-centric choreography approach has defined interacting artifact-centric processes [58,79]. Although flexibility is naturally deemed as one of the benefits from artifact-centric modeling approaches, a comprehensive study on supporting organizations to achieve all the three collaboration requirements is still missing. Based on literature and practices, we have observed that view-based approaches to inter-organizational business process management can provide a promising and efficient way of process modeling and change management to address such requirements; nevertheless, it has not been yet much explored in the context of artifact-centric inter-organizational business processes. Therefore, in this article, we are to explore the idea of process view in an artifact-centric perspective and develop a framework that can help organizations to meet the aforementioned requirements in a collaboration environment. We summarize our contributions as follows:

- We propose a formal artifact-centric view framework based on LTS (Labeled Transition System). This framework consists of three parts: (1) an artifact-centric Meta model for inter-organizational business processes, (2) notion of *private view* for capturing local processes of participating organizations, and (3) notion of *public view* for serving as an agreed contract of the collaboration. With public/private views, organizations are able to autonomously participate in the collaboration while being free to change their local processes.
- We design an algorithm for automatically constructing a consistent, minimal public view based on local processes of an organization. To the best of our knowledge, this is the first algorithm for automatically constructing a collaboration contract that takes into account interaction behaviors of artifacts.
- We develop a verification mechanism for artifact-centric processes that allows organizations to change their local processes, through the use of private views, while preserving the correctness and consistency of the overall collaboration. As the verification is performed locally, our mechanism does not suffer from the state explosion issue that may occur in global verification approaches.

The remainder of this article is organized as follows: Section 2 introduces the motivation of our artifact-centric

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