Available online at www.sciencedirect.com
ScienceDirect
Decision Support Systems 44 (2007) 266–284
Decision Support Systems
www.elsevier.com/locate/dss

Agile Integration Modeling Language (AIML): A conceptual modeling grammar for agile integrative business information systems ☆

Hong Zhang [a,1], Rajiv Kishore [b,*,2], Raj Sharman [b,2,3], Ram Ramesh [b,4]

[a] *Computer Information Systems, Glass Hall 376, Missouri State University, 901 S National Ave, Springfield, Missouri 65897, United States*
[b] *Department of Management Science and Systems, School of Management, The State University of New York at Buffalo, Buffalo, NY 14260-4000, United States*

Received 7 February 2006; received in revised form 16 March 2007; accepted 23 April 2007
Available online 13 May 2007

Abstract

The proliferation of newer agile integrative business information systems (IBIS) environments that use the software agent and the multiagent systems paradigms has created the need for a common and well-accepted conceptual modeling grammar that can be used to efficiently, precisely, and unambiguously, model agile IBIS systems at the conceptual level. In this paper, we propose a conceptual modeling grammar termed Agile Integration Modeling Language (AIML) based on established ontological foundation for the multiagent-based integrative business information systems (MIBIS) universe. The AIML grammar provides adequate and precise constructs and semantics for modeling agile integration among participating work systems in terms of quickly building and dismantling dynamic collaboration relationships among them to respond to fast-changing market needs. The AIML grammar is defined as a formal model using Extended BNF and first order logic, and is elaborated using a running example in the paper. The grammar is also evaluated in terms of its syntactic, semantic, and pragmatic qualities and is found to exhibit a high degree of quality on all these three dimensions. In particular, the pragmatic quality of AIML measured in terms of grammar complexity evaluated using complexity metrics indicates that AIML is much easier to learn and use as compared to the Unified Modeling Language (UML) for modeling agile integration of work systems in organizations.

Keywords: Conceptual modeling grammar; Systems modeling; Requirements specifications; Role-based modeling; Multiagent systems modeling; Integrative business information systems modeling

☆ The authors are grateful to Vijayan Sugumaran, participants at the SOM-Informatics Working Group seminar at SUNY Buffalo, and anonymous reviewers and attendees at the AMCIS 2003 and HICSS 2004 conferences for providing invaluable suggestions during the course of development of this paper. We are also grateful to Sukhamay Kundu for his critical evaluation of the AIML formal grammar included in the paper.
* Corresponding author. Tel.: +1 716 645 3507; fax: +1 716 645 6117.
E-mail addresses: HongZhang@MissouriState.edu (H. Zhang), rkishore@buffalo.edu (R. Kishore), rkishore@buffalo.edu (R. Sharman), rramesh@acsu.buffalo.edu (R. Ramesh).
[1] Tel.: +1 417 836 4121; fax: +1 417 836 6907.
[2] The second and third authors have contributed equally to this paper and their names are listed in the alphabetical order.
[3] Tel.: +1 716 645 3507; fax: +1 716 645 6117.
[4] Tel.: +1 716 645 3258; fax: +1 716 645 6117.

0167-9236/$ - see front matter © 2007 Elsevier B.V. All rights reserved.
doi:10.1016/j.dss.2007.04.009

1. Introduction

Information systems have been playing an important role in supporting business integration. Traditional integrative business information systems (IBIS) [18,19] such as ERP, EAI, and workflow management systems have brought significant benefits to businesses in terms of improved planning, timely deliveries, reduced inventories, reduced costs, and responsive and improved customer service [19]. However, they take significant amounts of time and effort to develop as all their component work systems[5] are tightly coupled to each other. Tight coupling also results in difficulties in adding new and modifying or deleting existing collaborative relationships among participating work systems. On the other hand, current hypercompetitive business environment requires business organizations to quickly build as well as dismantle dynamic collaboration relationships among various participating work systems, both internally and externally, to respond to fast-changing market needs.

Consequently, newer agile IBIS systems[6] should allow participating work systems to integrate with each other while preserving their local autonomy and coordinating in a decentralized manner. In an agile IBIS system, we envision no overall control over participating work systems and integration occurs through dynamic coordination among the participating work systems, in addition to the necessary integration at the technology and data levels [19]. In such a scenario, business processes are rather dynamic and emergent, relying on the judgments and decisions of individual work systems. To achieve this type of integration, an IBIS system should allow participating work systems to reach agreements about service contracts on their own without central control. Further, users and developers should be able to configure various business processes and collaboration relationships among work systems dynamically as the goals and needs of the organization change.

Recently, multiagent systems comprising of collaborating software agents have emerged as a new technology to solve complex problems in a distributed environment [40]. A software agent is "a computer system that is situated in some environment, and that is capable of autonomous action in this environment in order to meet its design objectives" [41]. An intelligent software agent within a multiagent system is autonomous (i.e., it acts without human intervention), reactive (i.e., it responds to events in the environment), proactive (i.e., it is goal-directed), and social (i.e., it interacts with other software agents to get what it needs) [41].

The multiagent systems paradigm has a number of parallels with the IBIS paradigm as noted in earlier work [19]. Further, due to their dynamic coordination and collaboration capabilities, software agents in multiagent systems are uniquely capable of supporting integration in agile IBIS systems as they provide flexibility in resolving inconsistencies and dependencies involved in work systems coordination. Further, software agent as a modeling paradigm minimizes the semantic gap between work system coordination and information system modeling [14]. As a result, software agents have been adopted by a number of researchers in various IBIS applications such as e-commerce [e.g., [16,28]], business process management [e.g., [15,21]], supply chains management [e.g., [12,33]], enterprise integration [e.g., [22,32]], and manufacturing [e.g., [10,20]] to create more agile integrative environments.

This proliferation of newer agile IBIS environments that use the software agent and the multiagent systems paradigms has created the need for a common and well-accepted conceptual modeling grammar that can be used to efficiently, precisely, and unambiguously, model agile IBIS systems. This is because existing modeling grammars such as ERD, object-oriented techniques, and business process modeling techniques lack requisite capabilities to model autonomy, intelligence, and agile coordination and collaboration that are central to agile IBIS systems. Most agent-oriented systems development methodologies also do not have conceptual-modeling-level constructs formally defined with unambiguous semantics. Further, researchers and designers that apply the software agent principles and concepts in various agile IBIS applications have defined their own unique and application-specific constructs and rules for conceptual modeling of agile IBIS systems which limits knowledge sharing and reuse in the agile IBIS community and may result in compatibility issues among future IBIS systems. In response to this state of craftsmanship, Kishore et al. [19] synthesized literature in the areas of IBIS systems and multiagent systems with the intent of developing a comprehensive foundation ontology for the universe of Multiagent-based Integrative Business Information Systems (MIBIS) that can become the basis for a sound conceptual modeling grammar for a variety of agile IBIS systems.

We extend Kishore et al.'s work and develop a formal conceptual modeling grammar termed *A*gile *I*ntegration

[5] A work system is "a system in which human participants and/or machines perform a business process using information, technology, and other resources to produce products and/or services for internal or external customers" [2].

[6] We use the term IBIS system in this paper for ease of reading even though the IBIS acronym includes the initial S for the term *system*.