The Journal of Systems and Software 108 (2015) 39–59

Contents lists available at ScienceDirect

The Journal of Systems and Software

journal homepage: www.elsevier.com/locate/jss

Mediation information system engineering based on hybrid service composition mechanism☆

Nicolas Boissel-Dallier[a,b,c,*], Fréderick Benaben[a], Jean-Pierre Lorré[b], Hervé Pingaud[a]

[a] Université de Toulouse - Mines Albi, 4 route de Teillet, 81000 Albi, France
[b] Linagora Toulouse, 3 Av Didier Daurat, 31000 Toulouse, France
[c] InteropSys, 23 Bd Victor Hugo, 31770 Colomiers, France

ARTICLE INFO

Article history:
Received 9 November 2012
Revised 11 May 2015
Accepted 31 May 2015
Available online 19 June 2015

Keywords:
Semantic web services
Interoperability
Mediation Information systems

ABSTRACT

Business-IT alignment nowadays has become crucial, with the expansion of service-based information systems and the need to collaborate with external partners. This research work therefore presents a hybrid service composition mechanism coupling logic-based and syntactic matchmaking of services and messages to transform a business process into an executable workflow. To meet the business requirements, this mechanism is based on both top-down and bottom-up approaches using available technical services and a generic semantic profile as pivot model. Whereas the service matchmaking focuses on the functional coverage of the generated workflow, the messageone generates the message transformation needed.

1. Introduction

In today's widely open business ecosystem, the ability to collaborate with potential partners is a crucial requirement for organizations. Furthermore, collaboration between organizations must be reactive (to catch any relevant collaboration opportunity) and flexible (to remain significant to the living situation). Besides, due to the crucial position of information system (IS) in nowadays organizations, collaboration of organizations strongly depends on the ability of their IS to collaborate (Benaben et al., 2010, 2013). Therefore, the concept of mediation could be extended to IS domain through a mediation information system (MIS) in charge of providing interoperability to the partners IS. Such a mediator should deal with information management, functions sharing and processes orchestration in a reactive and flexible way (to efficiently support the potential collaboration). The MISE 2.0 project (for MIS Engineering) deals with the design of such MIS. The MISE 2.0 is based on a model-driven engineering (MDE) approach, dedicated to provide reactivity (by ensuring automated model transformation) and is structured according to the following layers:

- Knowledge gathering (situation layer): collect information concerning the collaborative situation,
- Process cartography design (solution layer): design the processes according to the knowledge gathered,
- MIS deployment (implementation layer): implement an IT structure able to run the process cartography.

The transitions between these layers are the hard-points of this approach: Driving such a MDE approach to deploy a SOA (service-oriented architecture) system requires (i) to design a relevant business process cartography from the dedicated situation (first gap) and (ii) to design, from the obtained business processes involving business activities, a set of executable workflows invoking technical services (second gap). The first gap is managed at the abstract level of MISE 2.0 while the second one is managed at the concrete level of MISE 2.0. By filling both these gaps, one can assume that reactivity can be managed.

Furthermore, The MISE 2.0 deployment is based on a SOA dedicated to provide flexibility (by bridging the gap between design-time and run-time). The use of SOA allows to deploy on the same platform, on the one hand, services dedicated to design-time and, on the other hand, services dedicated to run-time. Design-time services include collaborative situation editor (dedicated to gather collaborative knowledge and to model the collaborative situation), business transformation service (dedicated to deduce, from collaborative situation model, the process cartography) and technical transformation service (dedicated to build, from process cartography, the executable workflow files). Run-time services include all the technical services that can be invoked to orchestrate the workflow files. Based on

☆ This document is a collaborative effort.

* Corresponding author at: InteropSys, 23 Bd Victor Hugo, 31770 Colomiers, France; Tel.: 0033634129815

E-mail addresses: boisseld@mines-albi.fr, nicolas@interopsys.fr (N. Boissel-Dallier), benaben@mines-albi.fr (F. Benaben), jean-pierre.lorre@linagora.com (J.-P. Lorré), pingaud@mines-albi.fr (H. Pingaud).

http://dx.doi.org/10.1016/j.jss.2015.05.064

this architecture, flexibility can be assumed: if an adaptation is required, run-time workflow orchestration can be interrupted and, depending on the nature of the required adaptation, any design-time service can be invoked in order to re-design new run-time workflows.

On a scientific point of view, the MISE framework may be described as follow, including the various key-points and contributions of these research works (distributed among the conceptual three levels):

- *Knowledge gathering (situation layer)*: this first layer includes (i) the use of a generic metamodel of collaboration (dedicated to collaborative situations) to formalize the situation, and (ii) the ontology-based semantic reconciliation during the characterization step.
- *Process cartography design (solution layer)*: the scientific stakes of the second layer are (iii) the quality of the automated deduction of a relevant collaborative behavior in BPMN (business process model and notation), i.e. the efficiency of the deduction rules, and (iv) the semantic and syntactic reconciliation between business elements and technical elements (data vs. information, activity vs. service, process vs. workflow).
- *MIS deployment (implementation layer)*: and (v) the automated deployment on a service-oriented middleware of an operational mediation information system (vi) the automated ability of the deployed system to detect and adapt the collaborative behavior to the possibly changing situation.

Key-points (i), (iii) and (v) are specific to the considered layers while stakes (ii), (iv) and (vi) concern the transitions between layers. This paper is clearly focused on the specific point (iv) of this framework, i.e. the transition between *solution layer and implementation layer*.

Our methodology, explained in Section 3 after a presentation of the study context (Section 2), aims at generating executable workflows from business processes. In order to perform this transformation, we first have to bring semantic information to our source models, thanks to our semantic annotation mechanism presented in Section 4. Afterwards, we can make use of this knowledge to find technical services which fit our business needs (see Section 5). In order to insure the good communication between those services, we then use our message matchmaking engine, detailed in Section 7. Then, Section 8 deals with evaluation of performance and limitations of this methodology. Finally, Section 9 concludes and presents research perspectives.

2. Positioning and related work

2.1. Mediation information system engineering and interoperability

The first iteration of MISE project (MISE 1.0, 2006–2010), did provide four design-time services dedicated to (i) characterize a collaborative situation based on a dedicated ontology (Rajsiri, 2010), (ii) extract and transform the knowledge embedded in that ontology in order to model a collaborative business process (Rajsiri, 2010), (iii) transform that collaborative business process model into a logical UML (unified modeling language) model of the mediation information system (Touzi et al., 2009) and finally (iv) transform this logical model into the files required for the deployment of an ESB (enterprise service bus) supporting efficiently the collaborative situation (Truptil, 2011). However, considering the first iteration, there were some weak points

- The collaborative situation ontology is mainly based on the MIT process handbook ontology (Malone et al., 2003) and is so essentially dedicated to manufacturing contexts.
- There is only one single collaborative process diagram deduced at the business level (merging decisional, operational and support considerations).
- Matching between business activities (included in the business collaborative process model) and technical services (included in the workflow model and deployed on an ESB) is a manual action.
- Detection of events requiring adaptation and flexibility mechanisms is also a human task.

The second iteration of MISE (MISE 2.0, started in 2009) aims at using the results of MISE 1.0 in order to improve the four previously presented drawbacks. As exposed in introduction section, it is based on two levels (abstract and concrete), dealing with the two transitions between three layers (situation, solution and implementation).

- By defining our own collaborative situation ontology, we aim at dealing with the first drawback (Mu et al., 2011).
- By using ISO standard, we aim at deducing a full process cartography (covering decisional, operational and support levels) and then at reducing the second drawback (Mu et al., 2011).
- By using semantic annotation of business activities, business information, technical services and technical information we aim at managing semantic reconciliation mechanisms (Hoang et al., 2010), in order to avoid the third drawback.
- By using an event-driven architecture, we aim at managing events and automatically detecting needs for adaptation (Truptil, 2011). Fourth drawback can then be avoided.

The first three points focus on design-time deduction and composition while the fourth point above takes interest into coupling this approach to runtime adaptation mechanisms (Barthe et al., 2014) in order to handle flexibility problems of such approach. In this view, the MISE project takes interest into crisis management cases, where solution has to be adapted to any situation change. This area is studied through french dedicated projects such as IsyCri (FR/ANR/SEC, 2007-2010, (Truptil et al., 2010)), SIM-Petra (FR/PREDIT, 2011–2013, (Mace Ramte et al., 2012)) or more recently GNPi (FR/ANR/SEC, 2014–2017).

The current paper details specifically the third point concerning semantic reconciliation.

2.2. Suitable solution for multiple application domains

Thanks to its flexible and adaptable mechanism, this approach is suitable for any application domain. A first iteration of this mechanism was developed during the ISTA3 project, which focused on subcontractors collaboration and insisted on information system interoperability as collaboration support (Boissel-Dallier et al., 2012). This project only took interest in semantic reconciliation (service discovery and message transformation generation) and insisted on industrial environment (limited agility needs, few potential services, basic performances). Since, This implementation is currently improving in order to meet more demanding activity domains such as nuclear crisis management (Barthe et al., 2011) or transport issues (Mace Ramte et al., 2012). As well as those projects need service and message matchmaking, they also take interest in the other features of MISE 2.0 such as business process generation and event-driven architecture. It allows the system to detect technical or business problem quickly, analyse it then adapt itself.

2.3. Service reconciliation: state of the art

With expansion of SOA architectures and BPM approaches, web service discovery and composition became a key factor for IT alignment. A lot of projects focus on it, most of them taking interest in semantic web service (SWS) possibilities.