A Conceptual Vision for Automated Business-to-Business Collaboration

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1 Introduction

By automating business-to-business (B2B) collaboration in a supply chain across several tiers, OEMs expect enhanced control over coordinating their suppliers and the latter parties hope to increase the effectiveness and efficiency of their service provisions. For supporting B2B collaboration, maturing and emerging technologies of service-oriented computing are available, e.g., UDDI [7], WSDL [9], SOAP [8], BPEL [13], WS-CDL [14], and so on. However, the B2B collaboration concepts do not support adequately an automated setup, enactment, and post-enactment of a supply chain. This paper investigates open issues for such full automatization based on a collaboration concept that has been developed for the CrossWork project [1] in which case studies with automobile-industry partners were conducted.

2 Dynamic Inter-Organizational Business Processes Management

A promising approach for B2B collaboration is the coupling of workflow management with service-oriented technologies. This framework of dynamic interorganizational business process management (DIBPM) [11] offers a new model for addressing the need of organizations for dynamically bringing together a service consumer and a service provider over web-based infrastructures where the service is a business process. A dynamic interorgani- zational business process is formed dynamically by the (automatic) integration of the subprocesses of the involved organizations. Here dynamically means that during process enactment collaborator organizations are found by searching business process market places and the subprocesses are integrated with the running process.

Related issues to DIBPM are the definition and identification of processes, the way compatible business partners find each other efficiently, the dynamic establishment of interorganizational processes, and the setup and coupling for process enactment. With respect to business-processes integration in DIBPM that is based on matching specific characteristics, various approaches are possible. The simplest matching approach is by name, which is only applicable in very simple or highly standardized cases. Attribute-based matching is performed by comparing business- process service values that are standardized within a specific domain, such that there are no semantics conflicts. Examples for attributes are the name of a service, the price in business-oriented matching, transactional properties like the presence of a particular compensation mechanism, or QoS dimensions such as service availability. Semantics-based business process matching is an extension of the attribute-based approach where attributes are compared based on ontologies that are realized with semantic web technology such as OWL-S [17]. Finally, a structure-based approach of business-process matching focuses on the structure (or behavior) of the process itself. A three-level framework [12] is a suitable model (see Figure 1) in order to manage in DIBPM such complex issues.

2.1 Structural Business-Process Matching

Within the framework of DIBPM, the concept of *eSourcing* [19–21, 18] focuses on structurally harmonizing on an external level the intra-organizational business processes of a service consuming and one or many service providing organizations into a B2B supply-chain collaboration. Important elements of eSourcing

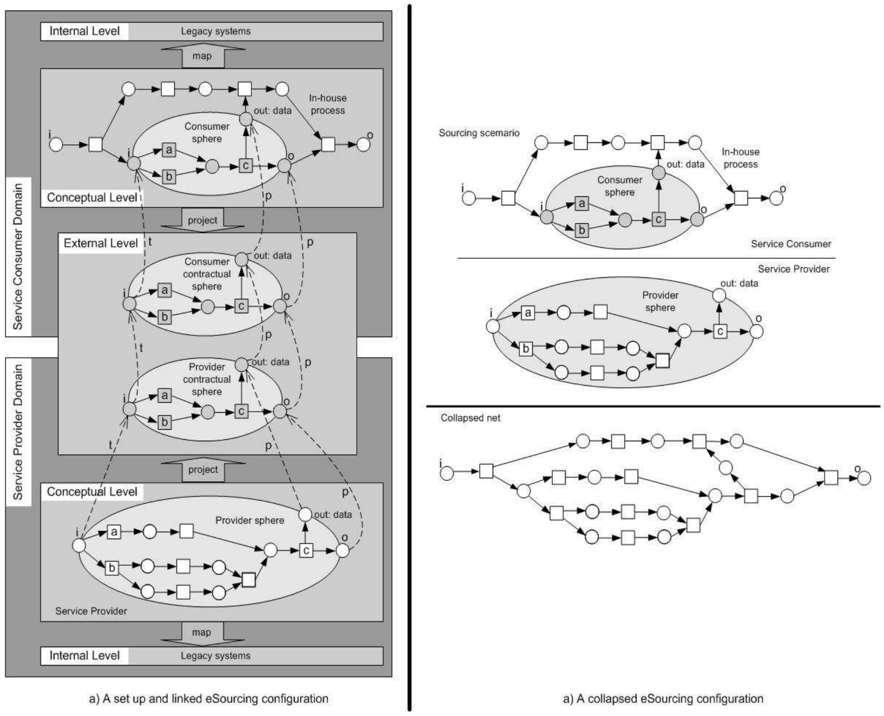

Fig. 1. eSourcing in a three-level business-process framework and its verification

are the support of different visibility levels of corporate process details for the collaborating counterpart and flexible mechanisms for service monitoring and information exchange.

On the left side of Figure 1, the three-level model is depicted as part of an eSourcing example. The very top and bottom show the internal levels of the service consumer and provider where processes are directly enactable by legacy systems, e.g., by workflow management systems. Using internal levels caters towards a heterogenous system environment. Furthermore, processes are designed on a conceptual level independent from infrastructure and collaboration specifics. In the center of Figure 1, the external level is stretching across the respective domains of eSourcing parties where structural process matching takes place. Either only interfaces, or parts, or all of the respective conceptual-level processes are projected to the external level for performing matching to realize automated and dynamically forged collaboration between partners. What is not projected remains opaque to the collaborating counterpart.

2.2 Structural Properties

The eSourcing example to the left of Figure 1 is modelled using labelled Petri nets [23, 24]. The special type of Petri nets used for the conceptual levels of eSourcing, namely workflow nets (WF-nets) [10], has one unique passive input node and one unique passive output node. Furthermore, all other active and passive nodes in a WF-net contribute to its processing. WF-nets carry the property of *soundness* [2, 15], which informally states that after the completion of a net, only one token must remain in the unique passive output node and all other passive nodes must be empty. WF-nets present an opportunity to verify the soundness before enactment of an overall process for ensuring a smooth enactment, e.g. with the powerful tool Woflan [25].

Starting with the domain of the service consumer in Figure 1, an in-house process is depicted on the conceptual level that is a WF-net. The in-house process contains a subnet termed a consumer sphere that is visualized with a grey ellipse. On the border of the consumer sphere, labelled passive nodes are called interface places. Only one interface place is *i*-labelled and only one is *o*-labelled. The other interface places are either *in* or *out*-labelled to denote an exchange direction of business-critical information between the in-house process and its contained consumer sphere. Furthermore, the labelling implies whether an interface place has an input arc or an output arc in the sphere. If an interface place is *i* or *in*-labelled, it has one output arc to an active node in the sphere. If an interface place is *o* or *out*-labelled, it has one input arc from an active node in the sphere.

The in-house process is mapped to the internal level of Figure 1 where legacy systems are located. The consumer sphere is enacted by a different party and therefore projected to the external level to become the consumer contractual sphere. From the opposite eSourcing domain a complementary provider contractual sphere is projected to the external level. Since the respective contractual spheres in Figure 1 are isomorph, a consensus is given between the eSourcing parties, which is the prerequisite for a contract [6].

The provider contractual sphere is complemented by a provider sphere on the conceptual level. Compared to the provider contractual sphere, additional nodes are contained. In Figure 1, such refinement is depicted by unlabelled active nodes in the provider sphere that do not exist in the provider contractual sphere. Hence, the refinement remains opaque for the collaborating counterpart. If the isomorph external-level processes are connected graphs, the refinement must be in accordance with *projection inheritance* [3] that is informally defined as follows. If it is not possible to distinguish the behaviors of processes x and y when arbitrary active nodes of x are executed, but when only the effects of active nodes that are also present in y are considered, then x is a subclass of y. Thus, process x inherits the projection of the process definition y while process x conforms to the dynamic behavior of its superclass by *hiding* active nodes new in x. Furthermore, such processes in an inheritance relation always have the same termination options. Note that Woflan [25] is also instrumental for verifying projection inheritance.

For relating the consumer sphere, the respective contractual spheres, and the provider sphere, the obligatory requirement of *well-directedness* of an eSourcing configuration must be fulfilled. This requirement focusses on the interface places of the spheres, which are part of what is considered exchange channels between spheres and the remaining in-house process. An eSourcing configuration is well-directed when the interface places of the consumer sphere, the respective contractual spheres of the service consumer and provider, and the provider sphere are equal in number and labelling.

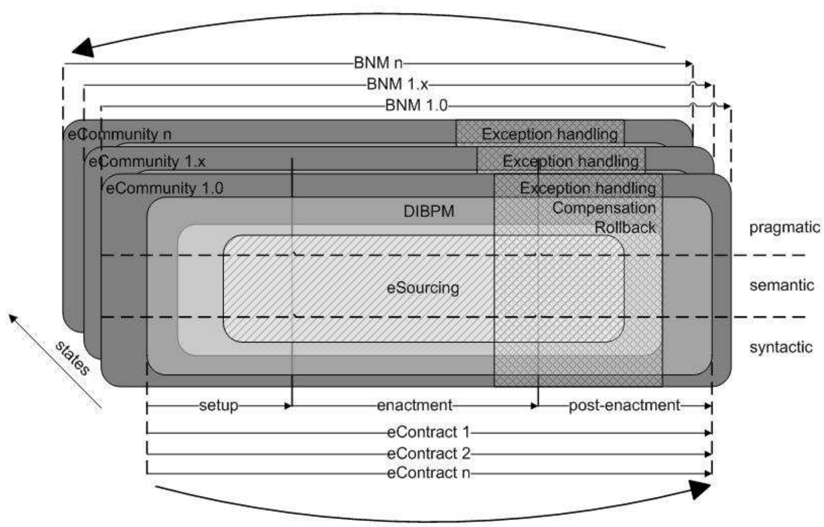

Fig. 2. A vision for the context of eSourcing.

Finally, in Figure 1 there exist referencing arcs connecting several passive nodes of the respective spheres. By using these referencing arcs, a transitive relationship is established between the consumer sphere and the provider sphere that ensures a correct start and end of service provision during the enactment of the eSourcing configuration. The notation of these referencing arcs of Figure 1 are part of so called monitorability patterns [22] that also cover the referencing of active nodes contained in the consumer sphere and the provider sphere. This way a variable degree of enactment-progress monitoring is possible for a service consumer.

2.3 Checking Structurally Matched B2B Collaboration

An eSourcing configuration is formally mapped to so called interorganizational workflow nets (IOWF-nets) [4, 19] so that a *collapsing* procedure is applicable for checking the correct termination on an interorganizational level. On the top right side of Figure 1, the in-house process and the provider sphere fulfill the well-directedness requirement. At the bottom right side of Figure 1, the collapsed net is depicted where the consumer sphere is removed and replaced with the provider sphere in the in-house process. As a result, the collapsed net must be a sound WF-net. If the projections to the external level result in isomorph contractual spheres that are connected graphs, the collapsed net must be a subclass net of the consumer in-house process according to projection inheritance. In any case, the overall process resulting from the collapsing procedure of an eSourcing configuration must always terminate correctly, i.e., be a sound WF-net. On the right side of Figure 1, the service provider adheres to projection inheritance. Scope for refinement flexibility is given as the provider is permitted to add nodes that do not violate projection inheritance. Note, it has been stated earlier that Woflan [25] can verify soundness and projection inheritance. By using Woflan as part of a trusted third party, the checking of eSourcing configurations is possible without forcing the collaborating parties into disclosing their business internals to each other.

3 Concluding an Integrated Vision for Electronic B2B-Collaboration

The eSourcing concept is suitable for structurally matching business processes interorganizationally and has been realized in proof-of concept artifacts [19] such as the business process coordination language eSML (eSourcing Markup Language) and eSRA (eSourcing Reference Architecture). These artifacts were applied in CrossWork [1] case studies and evaluation prototypes. However, a broader context needs to be born in mind for realizing automated B2B collaboration. Automatically integrated B2B collaborations are complex, open, dynamic systems of interrelated elements that pursue the objective of providing interorganizational business services for financial compensation. Such systems experience state changes of elements and their relationships, which are governed by dynamic mechanisms preventing the business collaboration from turning into a chaotic system of unpredictable behavior. Such dynamic mechanisms also include non-functional requirements such as trust, risk, privacy, reputation, and so on, that eSourcing and DIBPM do not incorporate.

To compensate this shortcoming, an extended vision for the context of eSourcing is depicted in Figure 2 that integrates several concepts. The involved collaboration complexity is tackled by including three dimensions. One dimension is a lifecycle of an automatically integrated business collaboration that has a setup, enactment, and post-enactment phase [5]. During the setup phase an offer is made to form an eCommunity [16] that is eventually defined in a business-network model (BNM). The eCommunity concept is adopted in Figure 2 to cater for an enhanced management of earlier mentioned non-function collaboration requirements. Changes of community members and their relationships result in updates of a BNM, e.g., a party of the e-business collaboration is voted out because of reputation problems, instead a different party is admitted because of the right degree of trust, and so on. Such changes result in a new state of a community, which Figure 2 visualizes with a separate dimension.

The collaborating parties engage in forming one or many eContracts [5] until signatures exist and they are stored. A real-world contract is a legally enforceable agreement, in which two or more parties commit to certain obligations in return for certain rights. Note that an eContract does not specify the same degree of non-functional requirements as a BNM specification. During an eContract enactment, service provisions are consumed for some compensation. In this phase exceptional situations may occur that are either resolved or that lead to the termination of individual enactment phases. The post-enactment phases are characterized by compensations and rollbacks, if any exceptions are not resolved during the enactment phases. Eventually, when no eContract need to be established and enacted any more, an eCommunity dissolves and its corresponding BNM is archived.

The third dimension focusses on establishing a separation of collaboration concerns with the values pragmatic, semantic, and syntactic. Pragmatic collaboration captures the willingness of parties to perform the necessary activities. The willingness to participate involves the capability to perform requested actions and policies that dictate whether the action is preferable for a party to be involved in an eCommunity. Semantic collaboration means that a message content is understood in the same way by a sender and receiver. Finally, syntactic collaboration means that messages can be transported from one application to another and correctly processed.

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