Well-Structured Inter-Oranizational Workflow Modeling for B2B e-Commerce

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초 록

최근의 기업들은 B2B 전자상거래 개념하에 상품과 서비스를 전자적으로 거래하기 위하여 자신의 기업 영역을 넘어서는 프로세스를 수행하고 있다. 이러한 환경에서, 조직간의 비즈니스 프로세스는 필요하며 파트너간의 공개 프로세스 뿐만 아니라 기업 내의 자체 프로세스도 잘 정의되어야 한다. 이러한 목적을 위해 이 논문은 조직간 비즈니스 프로세스를 나타내는 방법을 제시한다. 우선, B2B 전자상거래를 위한 조직간 워크플로우를 위한 모델링 방법을 제시한다. 이 방법은 1:1 및 1:N 협업시 공통 프로세스를 공유할 수 있도록 ebXML의 BPSS를 기반으로 제시되었다. 여기서 조직간 워크플로우의 설계 절차를 편리하게 하기 위해 메시지 플로우와 통제 플로우를 분리하였다. 둘째, 구조화된(well-structured) 조직간 워크플로우 프로세스를 설계하기 위하여 구조화된 프로세스 모델링 알고리즘이 제시된다. 이 알고리즘에서는 프로세스가 페트리넷 기반의 프로세스로 변환된다. 이 알고리즘은 하향식 방식으로 구조화된 프로세스 모델을 설계할 수 있도록 기능화된 (well-behaved) 모델링 블록, 기능화된 제어 구조, 비즈니스 트랜잭션을 이용한다.

Abstract

Today's enterprises take processes beyond their own organizational boundaries in order to electronically trade goods and services with partners under the concept of B2B e-commerce. In this environment, inter-organizational business processes are required and should be well defined not only in public processes between partners but in private processes within individual partners. For this purpose, we propose the method to represent inter-organizational business processes. First of all, a feasible modeling method for the inter-organizational workflow for B2B e-commerce is developed. This method is proposed based on BPSS in ebXML so that the binary and multiparty collaborations share a common process. In this method, message flows and control flows are separated in order to facilitate the design procedure of the inter-organizational workflow process. Second, a well-structured process modeling algorithm to design a well-structured inter-organizational workflow process is proposed. In the algorithm, a process is transformed to a Petri-net-based process model. This algorithm employs well-behaved modeling blocks, well-behaved control structures, and business transactions to develop well-structured process models by a top-down design.

키워드 :Process Model, Petri net, Inter-Organizational Workflow, B2B e-Commerce, Message Exchange, Business Transaction.

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1. Introduction

Though today's B2B standards such as EDI, RosettaNet, and ebXML, describe how to establish trading partnerships with specific commercial semantics and to execute business transactions between business partners, the problem of how to smoothly integrate intra-organizational business processes with B2B business processes is still a challenge. In order to solve this problem, many initiatives such as XPDL (XML Process Definition Language) by WfMC [6], BPML (Business Process Modeling Language) by BPMI.org [1] and BPEL4WS (Business Process Execution Language for Web Services) by OASIS[2] have provided modeling constructs that can be used to describe inter-organizational business processes. However, these approaches are based on the concept of "activity" which represents the lowest element in the decomposition of a business process. Therefore, they show the limitation in modeling the message flow of business process. Furthermore, they mainly fit to construct business processes from the viewpoint of one of the participants involved. This causes that the resultant process revolves around only one participant without consideration of partners' processes. Therefore, how to build the business processes which take partners' processes into account at the same time is still a challenge.

For this reason, we propose a new modeling method for inter-organizational workflow processes in B2B e-commerce which considers all partners' processes. The modeling method, which is depicted by Petri-net, takes partners' processes into account and has a capability to separate a whole process to multiple processes of individual partners. Our new method is much motivated by the ebXML BPSS paradigm. In contrast to other business process modeling approaches that represent the lowest level of decomposition of the business process with the concept of activity, the ebXML BPSS [4] adopts completely different approach to model business processes. This approach, though still message-based, regards the message exchange as the "unit of work" of the business process definition, and specifies binary collaboration as a message exchange, and then, packages the message exchange as a business transaction. Thus, an ebXML business process specification is the one of business transactions and the choreography of business transactions into business collaborations.

In our method, we extend the ebXML BPSS method to model the message exchanges between two business partners. The current ebXML BPSS provides two kinds of business collaborations: binary and multiparty collaborations. For the binary collaboration, BPSS provides well-known complete specifications that can be used to model the exchange of messages between two business partners. However, for the multiparty collaboration, BPSS provides little support but

a kind of logical synthesis of binary collaboration. Therefore, binary and multiparty collaborations have different schemas respectively. In addition, because current ebXML-compliant business process definitions include the message flows and the control flows together, the expressive capability of transitions between business transaction activities and pluggable control flows are much restricted. To date, an ebXML-compliant business process definition only involves the specifications of business transactions, business document flows, and binary collaborations that re-use the business transactions. However, it is completely feasible for these collaborations to share a common schema by a simple change of a BPSS binary collaboration definition, that is, just by changing the number of possible roles from exactly two to two or more. In this way, we can adopt the BPSS method to model the message exchanges between arbitrary two business partners.

2. Design of Public Business Processes for B2B e-Commerce

In the following, we illustrate our method of modeling inter-organizational workflows for B2B e-commerce by an example of the electronic bookstore that has no books in stock. First of all, we design public business processes over the business partners involved for the e-bookstore. This design takes four steps that include the specification of roles, message exchanges, business documents, business transactions, business activities and the control flows. The steps are as follows:

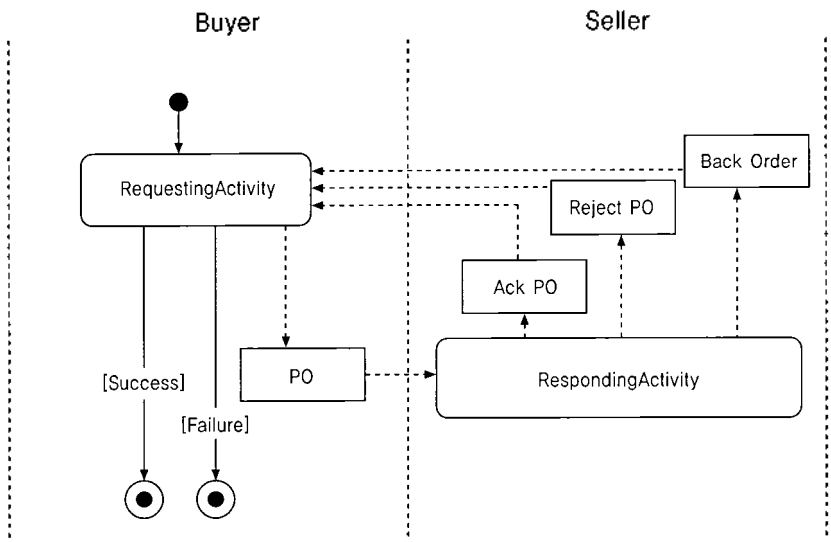
(1) Identify all roles, all possible message exchanges between arbitrary two roles regardless of the sequence of the message exchanges, and all the possible contracted constraints for the message exchanges between two roles (for instance, timeToAcknowledgeReceipt, timeToAcknowledgeAcceptance, isNonRepudiation-Required, and so on). These constraints can be stored in an XML file as attributes of business collaborations and used when specifying message flow controls.

As an example of message exchanges in BPSS, consider an application example of purchasing order that involves three possible responses: PurchaseOrderAcceptance(Ack PO), PurchaseOrderDenial(Reject PO), and PartialPurchaseOrderAcceptance(Back Order) (as shown in the Figure 1). Notice that in the actual execution of the purchase order transaction, only one of the defined possible responses will be sent. The seller has a service that receives a purchase order and responds with either acceptance (Ack PO) or denial (Reject PO) or even partial acceptance (Back Order) based on a number of criteria, including availability of the goods and the credit of the buyer. Obviously, the decision processes (that is

internal/private functions) are opaque, but the fact of the decision must be reflected as behavior alternatives in the external/public business process. In other words, the public process requires the selection of the branch, but the selection is nondeterministic from the perspective of the public process. In this situation, such non-determinism can be modeled by allowing the assignment of a nondeterministic or opaque value to a process variable, typically from an enumerated set of possibilities. In this way, the process variable can be used for defining conditional behavior that captures behavioral alternatives without revealing actual decision processes.

Refer to the ebXML BPSS specification for detailed semantics of these constraints [4]. This is very important for successful B2B E-commerce.

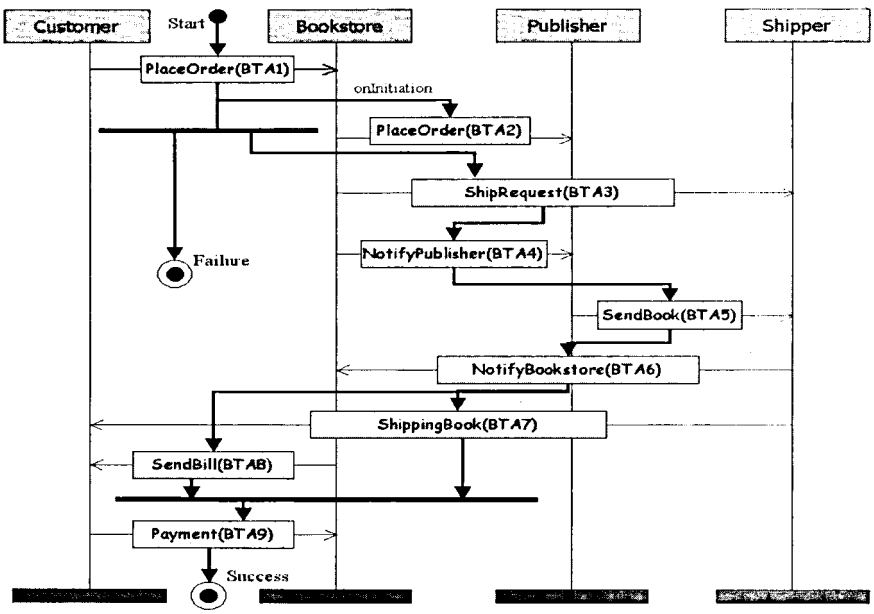
(2) Specify message flows and data flows. For this, it is necessary to identify payloads of each message and relations between different payloads, and then, to define a set of process variables that provide the means to hold the information that constitutes the states of a business process. It is very useful for the inter-organizational workflow management to specify state interactions that involve the exchanges of messages between business partners. The state of a business process includes the messages exchanged as well as intermediate data used in business logic and messages composition. In particular, some condition expressions can be attached to a response document to indicate the intent of a particular response.



〈Figure 1〉 Illustration for the Place Order with three possible responses[4]

(3) Define all the business activities. In this method, a business activity (also known as a business transaction activity in BPSS) is the performance of a business transaction, and a business transaction is an atomic unit of work in a trading arrangement between arbitrary two business partners. This will always either succeed or fail from a protocol and a business perspectives. The business transactions are re-usable relative to the business activities and realized as business document flows between the requesting and responding roles. There is always a requesting business document and optionally a responding business document, depending on the desired transaction semantics, for instance, one-way notification or two-way conversation. As mentioned above, the exchanged message may be a) one-way notification that is not logically related to any other message exchanges, or b) a request message followed by several possible responses.

(4) Define possible control flows by identifying possible transitions from one message exchange to another (that is, from one business activity to another) such that a public process is formed. This process can be viewed as a collection of business activities and executed by business partners involved within a value chain comprising multiple interacting organizations. Herein, each transition may have semantic constraints like timeToPerform in BPSS.



〈Figure 2〉 Illustration for the public business process model

Figure 2 represents the resultant model of the public business process that provides possible control flows of message exchanges for a typical purchase order. This is depicted by the UML activity diagram.

This case has four roles, i.e., customer, bookstore, publisher, and shipper. The customer places an order that is represented by PlaceOrder(BTA1). This customer order is sent to and handled by the bookstore. In this figure we use the attribute "onInitiation" that is defined in ebXML BPSS for a nested business transaction activity within a multiparty collaboration. In this research, we adopt this attribute to create a nested business activity. The bookstore then transfers the order of the desired book to the appropriate publisher that is represented by PlaceOrder(BTA2). The bookstore order is then evaluated by the publisher. The publisher in turn informs the bookstore of the availability of the book. If the customer receives a negative answer, the workflow terminates. In this figure, the upper synchronization bar allows us to evaluate conditions on the context of the place order and decide whether the PlaceOrder is accepted or not. If the book is available, the customer is informed of a positive answer and the bookstore continues processing the customer order. The bookstore sends a request to the shipper that is represented by ShipRequest(BTA3), and the shipper accepts or rejects the request after evaluation. If the bookstore receives a negative answer, it searches for another shipper. After a shipper is found, the publisher is informed of the shipper that is represented by NotifyPublisher(BTA4), the publisher prepares the books for shipment, and the book is sent from the publisher to the shipper that is represented by SendBook(BTA5). The shipper prepares the shipment and ships the book to the customer that is represented by ShippingBook(BTA7). The customer receives the book and the shipper notifies the bookstore that is represented by NotifyBookstore(BTA6). The bookstore in turn sends the bill to the customer that is represented by SendBill(BTA8). The lower synchronization bar is used only to synchronize different business activities. After receiving both the book and the bill, the customer makes a payment that is represented by Payment(BTA9). Then the bookstore processes the payment and the inter-organizational workflow terminates.

3. Modeling Inter-organizational Workflow Processes for B2B e-Commerce

We propose a process model in order to correctly refine the resultant public business process. In this model, Petri-net is adopted because Petri-net-based modeling technique is a well-known formalism for business processes

[3,5]. Petri-nets have a high expression capability and use graphical notations which enhance ease of use and understanding. Thus, Petri-net-based formalization for the resultant inter-organizational workflow process can be used to facilitate the modeling and analysis. Furthermore, the verification of the correctness of the workflow process definition can be addressed by using existing Petri-net-based analysis tools.

3.1 Well-behaved Building Blocks and Control Structures

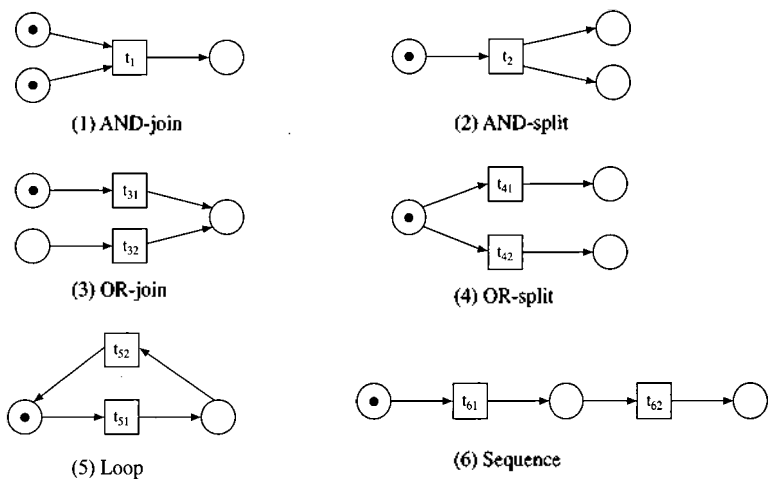
WfMC has defined six well-behaved building blocks that can be used to build well-structured process models[6]. Petri-net representations corresponding to the six well-behaved constructs are shown in Figure 3.

Similar to structured programming, we have modeled six well-behaved control structures, that is, parallel, selection, sequence, loop, begin and end structures, as shown in Figure 4. They are created by the combination of well-behaved building blocks proposed in Figure 3.

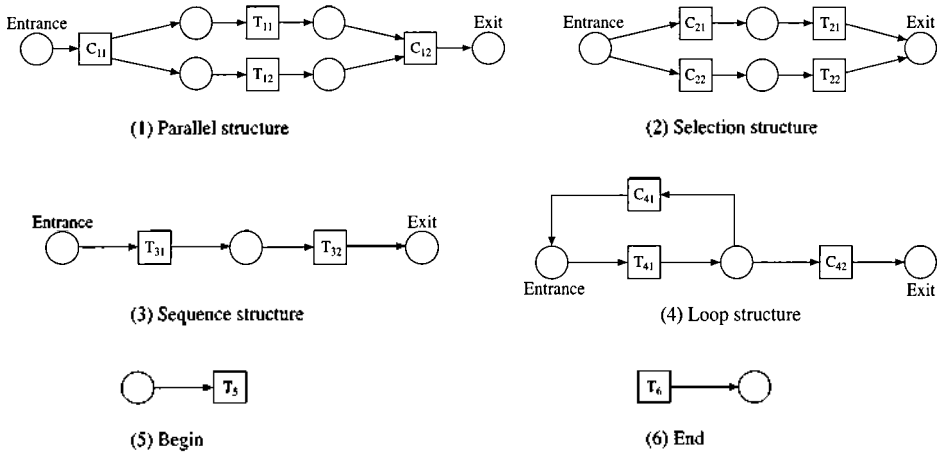
Note that there are two types of transitions in Figure 4, that is, control transitions (e.g., C11, C12, C21, C22, C41 and C42) that only take a role of routing controls, and task transitions (e.g., T11, T12, T21, T22, T31, T32, T41, T42, T5, and T6) that perform business functions.

3.2 The Modeling Algorithm for Well-Structured Inter-organizational Workflow Processes

In the following, we present the algorithm



〈Figure 3〉 Petri-net representations of WfMC's six well-behaved building blocks



〈Figure 4〉 Petri-net representations of six well-behaved control structures

to design well-structured inter-organizational workflow process models that include only six well-behaved control structures with a single entrance and a single exit. The modeling algorithm is as follows.

Step 1: The beginning of the business process is represented by the "Begin" control structure; the ending of the business process is represented by the "End" control structure.

Step2: Each business transaction in the business process becomes the corresponding Petri-net representation with dashed-line boxes as shown in Figure 5. When encountering a nested business transaction represented by the attribute "*onInitiation*" in Figure 1, , the abstraction transition representation can be used, which represents business transactions with coarse granularity. An abstraction transaction may be detailed as a sub-Petri-net representing a series of logically interested business transactions. For instance, as in Figure 5, business transaction ② can be nested in business transaction ①.

Step3: Each control flow is replaced by the corresponding well-behaved control structure. Any control structures, including sequence, selection, parallel and loop control structures, can be chained with "Begin" and "End" control structures by linking the corresponding transitions and places; and arbitrary two control structures except "Begin" and "End" control structures also can be chained together by merging the "Exit" place of one control structure with the "Entrance" place of the other control structure.

Step 4: Each transition except control transitions can be replaced by any of sequence,

selection, parallel and loop control structures, and any of Petri-net-represented business transactions. However, each replaced transition has a single "Entrance" place and a single "Exit" place. And then, its "Entrance" place will merge with the "Entrance" place of the replacing control structure, and its "Exit" place with the "Exit" place of the replacing control structure.

Step 5: Repeat step 3 and step 4 until all the control flows and abstract transitions are completely replaced.

For the illustration of the implementation of the modeling algorithm, we employ an example mentioned in the Figure 1. Due to the page restriction, the detailed proof for this transformation will be presented in this paper. The business process of e-bookstore in Figure 1 is transformed manually into a Petri-net-based inter-organizational workflow process as shown in the Figure 5. The transformation results in an inter-organizational workflow process that can be generated by means of above well-structured inter-organizational workflow process modeling algorithm. The details of the transformation of this example are explained as follows.

First, the Start and End that are represented by black dot and bull eyes in the Figure 2 respectively are transformed into the Begin and End control structures. Next, all the business transaction activities, that is, BTA1, BTA2, BTA3, and so on, are transformed into the corresponding Petri-net representations respectively as described in the Figure 5 with dashed line boxes that are labeled with ①, ②, ③, and so on, respectively, where BTA1, BTA2, BTA3 are two-way conversation. In particular, the BTA1 is at first transformed into the corresponding Petri-net representation that contains an abstraction transition. And then, this abstraction transition is further transformed into the corresponding Petri-net representation that is labeled with ②. BTA4, BTA5, BTA6 BTA7, BTA8, BTA9 are one-way notification.

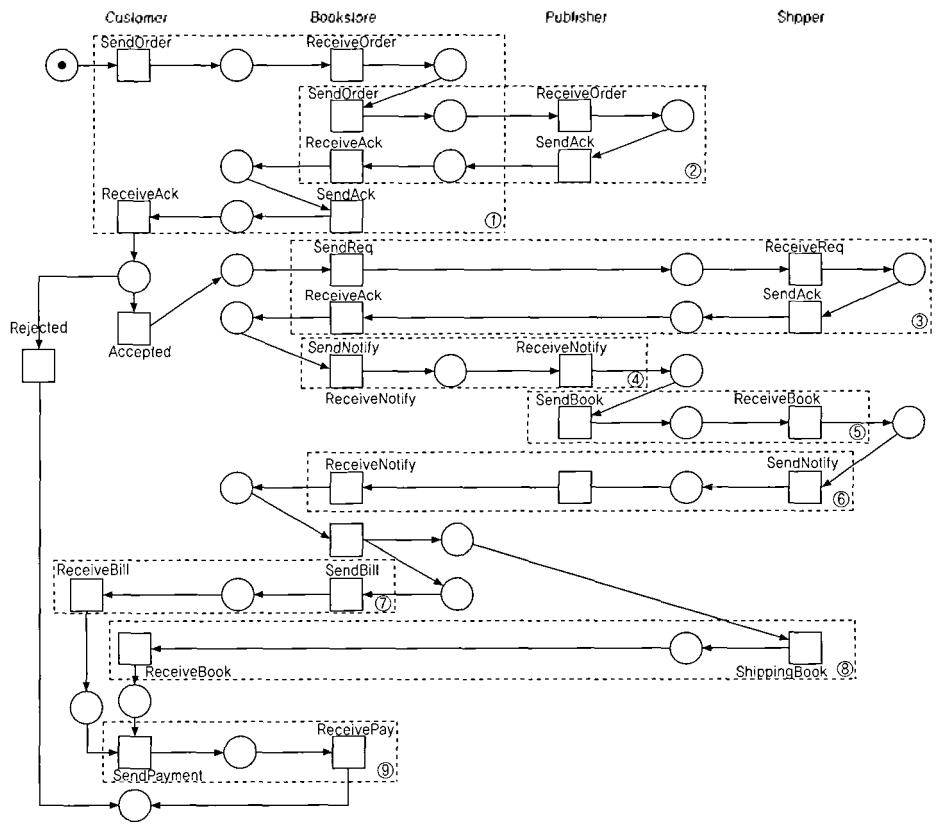
These structures of Petri-net representations can be chained together according to the steps 3, 4 and 5 of the algorithm and predefined control flows, because each Petri-net representation of the business transactions corresponds to a sequence structure. Therefore, as described in the figure, ③ is chained with ④; and then, ④ is chained with ⑤; and in turn, ⑤ is chained with ⑥ such that they together form a new structure. In succession, ⑦ and ⑧ form a parallel structure. This parallel structure again is chained with the previous-formed structure such that they all together form another new structure. Then, this new structure is chained with ⑨. In the succeeding of ①, there exists a conditional structure that contains two branches. One of them is replaced by above-formed new structure and the other stands for rejected branch. Last, the abstract

transition in ① is replaced by ②. The workflow process as shown in the Figure 5 is initiated by Customer's placing an order and then terminated by either the rejection from the Bookstore or the payment receiving of the Bookstore.

We can show that the resultant inter-organizational workflow process in Figure 5 is indeed a sound workflow process definition [5], since it has exactly one input place and one output place, at the moment when the workflow reaches the output place, all tasks have completed, and there are no dead transitions; that is, all tasks of the process nets are in fact reachable during workflow executions.

4. Conclusion

Current workflow tools do not provide an efficient approach to design an inter-organizational workflow process for B2B e-commerce. In this



〈Figure 5〉 An inter-organizational workflow process for e-bookstore

research, we proposed a modeling method for designing the inter-organizational workflows for B2B E-commerce. Different from existing approaches (such as BPML approach) that are based on the concept of "activity" which represents the lowest level of decomposition of a business process, the proposed method is based on BPSS in ebXML. This method not only facilitates the design procedure of the inter-organizational workflow for B2B E-commerce but also can be used to design decentralized business processes.

The proposed design of the public business process identifies all the key tasks, message exchanges, and the control and data dependencies between arbitrary two business partners. However, this public process does not involve the private processes of the individual business partners, that is, the customer, the bookstore, the publisher and the shipper. In our modeling method, the resultant inter-organizational workflow process can be generated from the public business process by the modeling algorithm and then partitioned over the business partners involved, such that the shared part for each business partner involved in the public process can be achieved. And then, the sharable process for the individual business partner can be formed by adding implicit places and arcs into the shared part, respectively. This sharable process can be applied to the WFMS which business partners use. In the context of the resultant inter-organizational workflow process, the shared parts for each business partner involved are related to each other. These sharable processes constitute the inter-organizational workflow process by means of the exchanges of the messages between business partners.

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