Integrating Workflow Management Systems with Business-to-Business Interaction Standards

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Business-to-Business (B2B) E-commerce is emerging as a new market with tremendous potential. Organizations are trying to link services across organizational boundaries in order to electronically trade goods and services. Standards such as RosettaNet, CBL, EDI, OBI, and cXML, describe how electronic B2B interactions should be carried on so that dynamic trade partnerships can be established and transactions can be executed across organizations. While the development of standards is a fundamental step towards enabling e-business, the problem of linking B2B interactions with internal business processes, and therefore of implementing B2B solutions, is still a challenge. In addition, as the industry standards evolve continuously based on changing needs, organizations have to adopt new standards quickly. In this paper we describe how workflow technology can be extended in order to support B2B interactions and to link them with the internal workflows. The proposed framework can be used to speed up both the development of new business processes that support B2B interaction standards and the enhancement of the existing business processes by the addition of B2B interaction capability. We demonstrate the benefits of our framework through an example in which we describe how RosettaNet Partner Interface Processes (PIPs) can be interfaced with HP Process Manager (HPPM), HP's business process management product that was formerly known as Changengine. An analogous solution can be developed for other workflow management systems and B2B interaction standards.

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1. Introduction

Organizations need to integrate their processes in order to efficiently trade goods and services electronically, and perform e-business transactions. Several industry standards, such as RosettaNet [Geref01] and the Common Business Library (CBL) [Xcbl], are being developed in order to allow organizations to interoperate, by defining common ontology, syntax for message exchanges, and flow of interactions among the business processes across organization boundaries. In order to interact with a trade partner, an organization must not only be able to send and receive messages and carry out conversations according to a specific standard, but also be capable of coordinating the *internal* business processes with the *external* interactions. In addition, since B2B standards are constantly evolving as a result of the changes in the technology and needs of organizations, it is necessary to quickly and easily adapt to the changes in the standards. The implementation of new standards and their integration with the internal business processes often require a lot of manual effort and take many months to complete. Moreover, the users (designers of internal business processes) are usually required to deal with the details of B2B conversations, message formats, data mapping, etc. The users should concentrate on designing the business logic of their organizations' business processes, rather than worrying about the details of B2B interaction standards. There exist many standards already in use or under development. Enterprises have to support many different standards in order to be able to carry on trade partnerships with multiple partners, because each partner might have adopted a different standard. In summary, even after B2B interaction standards are defined, there exist many important challenges that need to be addressed in order to build and operate on-line trade partnerships quickly and easily. Those challenges are summarized as follows: minimizing the manual effort in integration of existing and new *internal* business processes with *external* B2B interaction standards, adapting to the changes in B2B interaction standards, hiding B2B interaction details from the users, supporting multiple B2B interaction standards in conversations with the trade partners.

Organizations may often need to carry on a *conversation* (i.e., exchange several messages with one or more business partners) in order to accomplish B2B interactions. Unfortunately, most B2B standards do not describe the complete conversational logic between trade partners. Some standards, such as EDI [Benesko95], only describe how individual transactions should be carried on. Some others, such as OBI [Obi01] and cXML

[Cxml00], describe the contents of individual message exchanges. RosettaNet and CBL are two recently initiated B2B interaction standards that aim at describing the complete conversational logic between trade partners. Although those standards describe the contents of individual messages in a structured format, using either XML DTDs or schema language, the overall conversational logic is described as a combination of flat text and graphical representation (UML diagrams). In other words, those conversational logic descriptions aim the humans as the target audience. Process designers are supposed to read, understand, and implement the conversational logic themselves. Thus, a lot of manual effort is required to implement those standards and it is very hard to develop a software tool that can automatically generate an implementation of those standards.

Business processes are often automated using Workflow Management Systems (WfMS) [Leymann99]. WfMSs are tools that enable model-driven design, analysis, and simulation of business processes, which can be designed from scratch or from templates that support rapid application development. WfMSs also provide features for monitoring the execution of business processes and for automatically reacting to exceptional situations. The integration of WfMSs with Enterprise Application Integration (EAI) tools further increases the effectiveness of these systems, and enables them to handle the two crucial aspects of process automation: end-to-end process flow management and interaction with the (heterogeneous) invoked applications. Finally, enhancement of WfMSs with support for B2B interaction standards will result in complete automation of business operations both within and across organizational boundaries.

In this paper, we explain how workflow technology can be extended to support B2B interaction standards, and address the problems that are mentioned above. The main contributions of this paper are the following:

- Organizations that develop B2B standards describe only the common syntax, ontology, message content, and flow in B2B interactions, but they do not address the issues of integrating the internal workflows of enterprises with those standards. Therefore, the integration of internal workflows with the B2B standards requires a lot of manual work, and prohibits the use of standards by most small and medium sized companies. We explain a complete methodology for integrating the B2B interaction standards with internal workflows of organizations. There has not been any research publication explaining how to do such integrations. There are very few commercial products that provide tools for integration with internal workflow management systems, but there is not any

explanation of how to generate templates from the definitions of standards, and how to use those templates while building new workflow processes or enhancing the existing ones with B2B interaction support.

- We explain how to hide B2B interaction details from business process developers by using a tool that provides mechanisms to map between internal and external data formats, and to manage data exchanges that comply with the pre-defined document formats of B2B interaction standards. This tool can use multiple B2B interaction standards, provided that the required templates for those standards are generated beforehand. In this paper, we explain how this tool can be used to support RosettaNet PIPs, as an example.
- We explain not only how to generate new workflow processes that support B2B interaction standards, but also how to enhance the existing process definitions with B2B interaction capabilities using process, service, and document templates that can be generated through the proposed methodology in this paper.

The rest of this paper is organized as follows. Section 2 summarizes the most commonly used B2B interaction standards. Section 3 describes the basic workflow concepts and process definition in HP Process Manager (HPPM). Overall view of the proposed solution is explained in section 4, and the details of its three main components are given in the following sections: service library, process templates, and conversation manager. Section 8 explains the four main steps of the proposed solution and provides an example of developing a complete business process using our solution. Section 9 summarizes the related work. Section 10 explains the benefits of the proposed solution, and makes concluding remarks.

2. B2B interaction standards

Industry standards, such as RosettaNet, Common Business Library (CBL) and Electronic Data Interchange (EDI), Open Buying on the Internet (OBI), and cXML (Commerce XML), provide guidelines to achieve interoperability among the supply chain processes of individual organizations. The standards define common ontology, syntax for the message exchange, and interactions across organization boundaries.

EDI provides a collection of standard message formats and element dictionary in a simple way for businesses to exchange data via any electronic messaging service. Its main goals are to reduce paper consumption, eliminate data entry errors, and speed up transfer of business information.

cXML (Commerce XML) is a new set of document type definitions (DTD) for the XML specification. cXML works as a meta-language that defines necessary information about a product. It will be used to standardize the exchange of catalog content and to define request/response processes for secure electronic transactions over the Internet. The processes include purchase orders, change orders, acknowledgments, status updates, ship notifications and payment transactions. The cXML initiative is complementary to existing XML initiatives led by CommerceNet, RosettaNet, Information & Content Exchange (ICE) and Open Buying on the Internet (OBI).

The Open Buying on the Internet (OBI) standard is an open, flexible framework for B2B e-commerce solutions. It describes the B2B interactions using four main components: Requisitioner (a web user who initiates the interaction), Selling Organization (the supplier), Buying Organization (the client), and Payment Authority (the payment department of the buyer). The message exchanges in OBI support the existing EDI standard.

CBL [Xcbl] was originally developed by Veo Systems Inc., which was acquired by CommerceOne. Veo Systems has turned over CBL to CommerceNet, an industry consortium that is promoting interoperable commerce on the Internet. CBL provides a set of building blocks with common semantics and syntax to ensure interoperability among XML applications. It consists of information models for generic business concepts, such as business description primitives (company, service, product), business forms (invoice, purchase order, catalog), and standard measures (date, time, location, classification code). Schema languages are preferred in CBL over the XML DTDs since schemas allow strong data typing, but DTDs are also supported for compatibility reasons.

RosettaNet [Geref01] is a consortium of more than 350 companies in the Information Technology, Electronic Components, and Semiconductor Manufacturing supply chains including HP, IBM, Compaq, Cisco, Intel, NEC, Dell, Lucent, SAP, Microsoft, and many other leading companies. RosettaNet's main focus is providing interoperability through aligning business processes. The consortium is driving the development

of Partner Interface Processes (PIPs) that define the interaction standards for a broad set of supply chain scenarios, and dictionaries that provide the data standards and common product descriptions within the PIPs.

A PIP describes the interactions between business processes across enterprises. PIPs explicitly include the notion of conversation. A conversation identifies the context in which multiple message exchanges are carried on between the same parties. As an example, Figure 1 shows the interactions during a quote request, as described in RosettaNet PIP3A1 (Request Quote). The actions "Quote Request" and "Quote Response" correspond to the message exchanges between two business processes running in different organizations. The activities "Request Quote" and "Process Quote Request" represent the activities within the internal business processes of those organizations. The figure describes the actions that take place during a product quote request in the form of a state machine. The states are denoted $S_1..S_7$, and the transitions between those states are denoted $T_1..T_7$.

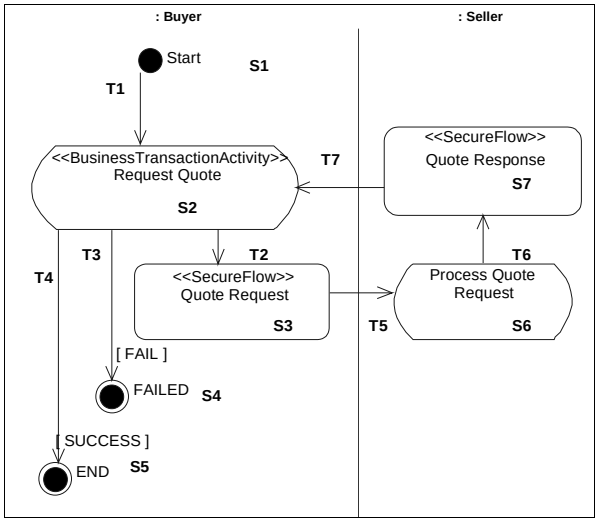

Figure 1 – RosettaNet PIP 3A1 (request quote)

3. Basic workflow concepts and HPPM

WfMSs are used to define, validate, and automatically manage and monitor the execution of operations (*business processes*) in organizations. In this section, we define the basic workflow concepts that are used in the rest of this paper, and explain how those concepts are described in HP Process Manager (HPPM) [Hppm00], which is HP's workflow management product that was formerly known as Changengine.

WfMSs often allow graphical description of actions that need to take place during the execution of business process, and overall flow of process. The process flow is shown as a directed graph, in which *nodes* represent the action points and *arcs* (arrows) between those nodes describe the flow of the process execution among those nodes. Each node is associated with a *service* (action) to be performed when the process execution reaches that node. The services are performed by *resources*, which are either humans or software tools, such as database management systems, catalogue management programs, e-mail servers, etc. Figure 2 shows a typical HPPM process definition as it is displayed on HPPM's process definer tool. A process definition includes four types of nodes:

- **Start Node** represents the actions taken during the initiation of a new process instance.
- **End Node** represents the end of a process execution.
- **Work Node** represents an action step in the process definition. Each work node is associated a service, representing the action being taken at that node.
- **Route Node** represents a decision making step of the process flow that may cause one alternative path to be executed among multiple alternatives. In addition, a route node is used to indicate the beginning or end of loop, or multiple execution paths that are carried on in parallel.

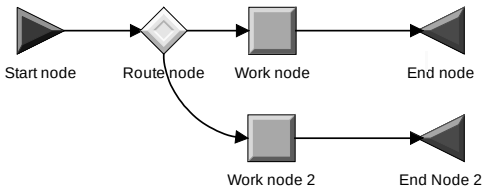

Figure 2 – HPPM process definition

4. Proposed Solution

The proposed solution includes the following components:

- **B2B Service library:** stores predefined sets of workflow activity definitions, made available to the workflow designer, that can be reused in a workflow to send and receive B2B messages, and transfer data between those messages and workflow variables. *B2B services* are the services in

which an interaction with a trade partner (a single message exchange or a conversation with another organization) takes place.

- **B2B Process templates:** reusable process skeletons that implement the *conversational* logic according to a given B2B standard (such as a RosettaNet PIP), and can be extended by process designers to include the required *business* logic. The process templates and B2B service library can be used to speed up and ease the development of workflow processes that have the B2B interaction capability.
- **Trade Partners Conversation Manager (TPCM)**: an application that executes B2B services by mapping the internal workflow data representation into the format required by the standard and vice versa, and by managing conversations.

Our solution for extending workflow technology to support B2B interaction standards consists of four main steps:

1. Structured description of complete B2B conversations, as well as the contents of individual message exchanges, in the industry standards. That means, the developers of industry standards are expected to prepare structured descriptions of B2B conversations.
2. Creation of B2B service and process templates from the descriptions of B2B interaction standards.
3. Enhancement of internal workflow processes with B2B interaction capability. This enhancement falls into two categories: creation of new processes that support B2B interactions, and enhancement of existing internal processes so that they could carry out B2B interactions with the trade partners.
4. Execution of enhanced processes, which are managed by a WfMS and a conversation manager (TPCM). The WfMS manages and monitors the processes as usual, and the conversation manager executes the B2B interaction steps (B2B services) in those processes.

Figure 3 provides an overview of the proposed approach. The workflow designer specifies processes by reusing process templates and extending them by adding conventional or B2B services. The B2B service library and the process templates are design tools that support the process designer in implementing B2B processes without needing to know the details of the standards (or even to know that a specific standard is

being followed). During process execution, the TPCM takes care of executing all B2B services and communicating with business partners according to the adopted B2B standard.

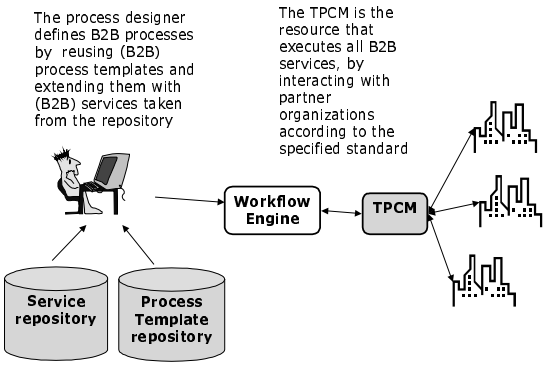

Figure 3 - Overview of the proposed approach

In the following three sections, we describe the details of the three main components that are included in the proposed solution. In section 8, we describe our four-step methodology, and provide an example for developing a complete business process using those four steps.

5. Service Library

In order to minimize the manual effort in workflow design and implementation, and to allow designers to focus on the business logic required in the interactions rather than message formats and message exchange protocols, a set of *B2B services* is made available in the WfMS service repository. These services are generated automatically as it will be described in section 8. There are two types of B2B services in the repository: the first one (*B2B Interaction* services) includes services that can be associated to work nodes, while the latter (*B2B Start* services) includes services that can be associated to start nodes.

5.1 B2B interaction services

A B2B interaction service represents a B2B message to be sent to or received from a business partner, or a two-way message exchange. When the designer needs to define a workflow in which a B2B message should be sent to or received from another organization, he or she simply creates a work node in the process

definition and binds that node to a predefined B2B service. TPCM handles mapping and packaging of input/output data, the delivery of the message to the partner organization, the receipt of the reply and extraction of data from it to be inserted into the service output items. Thus, the process designer does not need to be concerned with those details. Hence, the definition of a new workflow (or the enhancement of an existing one) that interacts with a business partner is made simple and fast.

The definition of a service includes all the input and output data required to handle the message exchange (i.e., to generate the outbound message and extract data from the reply). In addition to the message-specific input and output data items, all B2B services include the following data items: *B2B partner* (if not specified, a default value partner, typically a broker, specified at the TPCM level is used. This approach is very useful to simplify process definition and management in those situations where all interactions go through a broker/dispatcher such as Viacore [Chehade99]), *B2B Standard* (if not specified RosettaNet is the default), *Discard reply* (indicates if a reply is expected or not), *Termination status* (return value of the service), and *Conversation ID* (used for keeping track of conversations that involve multiple message exchanges with the same trade partner).

5.2 B2B start services

Start services are associated to start nodes, which represent the actions during the initiation of new process instances. B2B start services are used for initiating particular process instances when a predefined B2B message is received. When a designer needs to define a process that is activated upon receiving a given B2B message, he or she can associate the B2B start service corresponding to the message with the start node of the process. The TPCM takes care of starting a new instance of the process when such a message arrives, thereby also filling in the process input data, extracted from the message.

6. Process Templates

Process templates are skeletons of workflows that can be reused and extended in order to implement a conversational standard. The skeleton defines the conversational logic according to the protocol defined by a particular standard, and can be extended by the process designer to define the business logic. Figure 4 shows

an example template process, which handles “RFQ (Request for Quote)” messages. The process template is listed in the TPCM repository as the process to be started when an RFQ message is received.

Work node rfq_reply takes care of sending the quote to the requestor. In addition, a parallel path including the work node *rfq_deadline* is started. The node is a dummy node, but it includes a deadline that expires after the maximum time allowed by the RosettaNet specifications for a quote has elapsed, which causes the process to terminate in the *expired* end node.

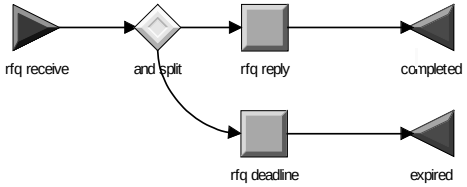

Figure 4 - Process template for managing RosettaNet RFQs.

When defining a process to provide a quote, the designer may extend the template to include the appropriate business logic, thereby inserting additional nodes, flows, and data items, as shown in Figure 5. Work nodes *rfq_deadline* and *rfq_reply* are analogous to the ones in Figure 4. It is possible to submit an error message to the trade partner or an authorized person within the organization when the deadline expires. In order to include that capability in the process, it is sufficient to add a work node that is associated with such a service. Similarly, work node n*otify admin* is associated with a service that sends a message to the sales administrator of the organization when the deadline expires.

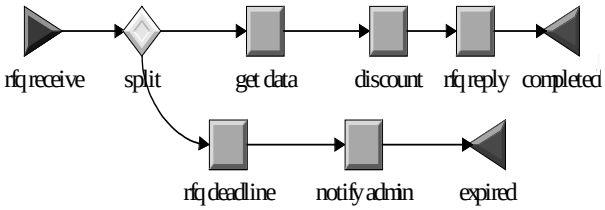

Figure 5 - Process templates can be extended to include the business logic

7. Trade Partners Conversation Manager

The TPCM is an application that acts as a workflow resource. It executes B2B services by sending a B2B message to a partner and possibly waiting for a reply and extracting data from it before returning the service

to the WfMS. The TPCM can also be instructed to activate a given process instance when a B2B message of a specified type is received. We first describe the content of the repository on top of which the TPCM operates, then we show how the TPCM works.

7.1 The TPCM repository

The TPCM has a repository that includes two information items for each B2B service defined in the service library: an *XML template document*, conformant to the DTD (or XML schema) of the outbound message type, and a *set of XQL queries*, one for each output data item of the service. The XML templates are used by the TPCM to generate the outbound messages as B2B services are invoked. XML templates may include references to the service input data (marked with %% signs), in order to customize the message with process instance specific data. XQL queries are used by TPCM to parse received XML documents and feed received data into the service data items.

As an example, Figure 6 shows the XML document template and a few queries associated to the RFQ service. XML templates are generated from the XML DTD or schema language definitions that are provided by B2B interaction standards. Any reference to a service data item name is included between double percent symbols, e.g. *%%Contact_Name%%*. While preparing a B2B message, TPCM retrieves the XML template from the repository; replaces service data item references with the actual value of those data items; then submits the B2B message, containing the XML document, to the trade partner.

```
<?xml version="1.0"?>
<Pip3A1QuoteRequest>
  <fromRole>
    <PartnerRoleDescription>
      <ContactInformation>
        <contactName>
          <FreeFormText xml:lang="en-US">
            %%ContactName%%
          </FreeFormText>
        </contactName>
        <EmailAddress>
          %%ContactEmail%%
        </EmailAddress>
        <telephoneNumber>
          %%ContactTelephoneNumber%%
        </telephoneNumber>
      </ContactInformation>
      …
    </PartnerRoleDescription>
  </fromRole>
</Pip3A1QuoteRequest>

Example XQL queries:
  ContactInformation/contactName/FreeFormText
  ContactInformation/EmailAddress
```

Figure 6 – An XML document template and a set of XQL queries for parsing that document.

7.2 Execution of B2B services

In order to submit B2B messages, the TPCM operates as it is shown in Figure 7. Depending on the WfMS operation, TPCM either periodically polls the WfMS to check if there is a B2B service to be executed, or waits for the notification message of a particular event occurrence from the WfMS. Then, it retrieves service name and input data from WfMS (step 1 in figure 7). Next, the XML template that is associated to the service is retrieved from the repository (step 2). After that, TPCM generates the outbound message, and replaces all the references to service input data items with their actual values (step 3). Finally it sends the document to the partner specified by *B2B Partner* input data item (step 4).

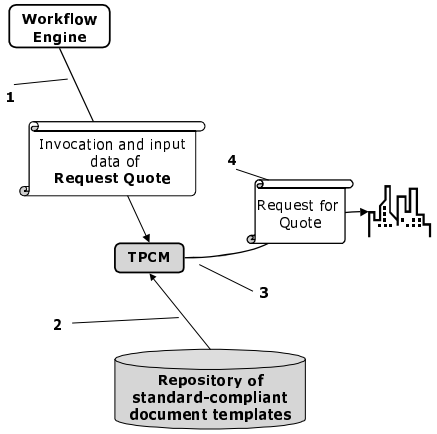

Figure 7 - Invocation of a B2B service and generation of the corresponding B2B message.

If no reply is expected after a message submission, TPCM returns the completed service results to the WfMS. Otherwise, it waits to receive a reply. The activities upon receiving the reply are summarized in Figure 8. When the reply arrives (step 1 in the figure), the TPCM accesses the repository in order to retrieve the set of XQL queries associated to the service (step 2). Then, for each output data item, it executes the XQL query associated to it, thereby extracting data from the reply document (step 3) and making them available to the data items of the B2B service (step 4). Figure 9 shows a sample RFQ reply and the values assigned to the service data items.

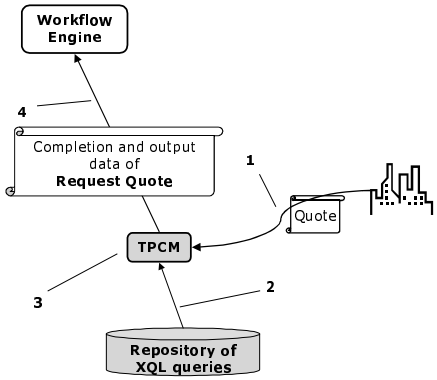

Figure 8 - Completion of a B2B service upon receiving the (standard-compliant) reply from the partner

```
<?xml version=”1.0”?>
<Pip3A1QuoteResponse>
  <fromRole>
    <PartnerRoleDescription>
      <ContactInformation>
        <contactName>
          <FreeFormText xml:lang=”en-US”>
            Mary Brown
          </FreeFormText>
        </contactName>
        <EmailAddress>
          amy@mycompany.com
        </EmailAddress>
        <telephoneNumber>
          1-323-5551212
        </telephoneNumber>
      </ContactInformation>
      …
    </PartnerRoleDescription>
  </fromRole>
</Pip3A1QuoteResponse>
```

Figure 9 – A sample RFQ reply in XML format

7.3 Message-driven process instantiation

The TPCM can be instructed to activate a process instance in order to process a request coming from a business partner. When the TPCM receives a message that is not a reply to a previous request, it checks if there is a B2B start service associated to the messages of that type. If so, it retrieves the XQL queries associated to the service data items, executes them against the inbound message in order to extract the data to be inserted into the input data items of the service, and then starts the process by executing the service associated with the start node of that process.

7.4 TPCM implementation

This section provides details about the current TPCM implementation, and in particular about how message exchanges are managed.

After sending a request to a trade partner, the XML document response is received by a daemon process that listens to a specific port for the incoming messages. The data is extracted from the document, and mapped into the service data items. The TPCM has to know which service instance of which process instance had initiated the request, so that the response can be delivered to that service instance. Therefore, when submitting a message across the organizational boundaries, TPCM needs to keep record of the service and process instance that is relevant to the message. The TPCM needs the following information from the service instance that wants to submit an interaction message to an external organization: name of the trade partner to which the message is going to be sent, and process instance and service identifiers for the B2B service that submitted the message. The TPCM also keeps a table that maps a trade partner name into the IP address and port number of a trade partner.

In addition, a document identification number is automatically generated by the TPCM in order to uniquely identify the document that is being submitted, and its response. The document identifier is piggybacked in the response message. The TPCM records the document, process instance, and service identifiers in a repository so that it can find out the process instance and service when the response arrives with the same document identifier in it.

8. Methodology

8.1 Automatic generation of B2B service definitions from structured definitions of standards

Individual message exchanges between trade partners are defined as a collection of XML DTDs or schema language definitions, depending on the industry standard that is used. Therefore, B2B service definitions are generated from XML DTD or schema language definitions, and contain the inputs and outputs that are necessary for XML document exchanges. TPCM hides the details of the B2B interaction standards and message exchange protocols from the service definition.

8.2 Automatic generation of process templates from structured definitions of standards

As an example, we explain generation of process templates from RosettaNet PIPs (Partner Interface Processes), but this example can be easily extended for other standards. The PIPs describe the conversational logic as a combination of textual and graphical representations. The overall flow of a PIP is described as a UML (Unified Modeling Language) graph, and the details, such as the deadlines, roles of business partners, etc., are explained as flat text. Therefore, users (process definers) are supposed to read the PIP definitions, and develop or modify the business processes accordingly. This manual development takes a long time, and it is very hard to automatically generate RosettaNet compliant business processes or adopt RosettaNet PIPs in existing business processes, because it is difficult for an automated tool to interpret those graphical and unstructured textual representations. However, if RosettaNet PIPs were represented completely in a structured textual format, it would be possible to automatically generate process templates that support RosettaNet PIPs.

XMI (XML Metadata Interchange) aims at combining the benefits of XML, UML and MOF standards, and it is being widely used for the textual description of UML diagrams. Therefore, we suggest that in the future, the conversational logic of RosettaNet PIPs and other standards can also be defined in XMI by the developers of those B2B interaction standards. We explain the creation of process templates from structured definitions of B2B interaction standards in two parts: (1) describing B2B conversational logic, such as a PIP, in XMI; (2) generating a process template from an XMI definition. Figure 10 shows the first three steps of our methodology. First, XMI definitions of B2B standards are prepared. Then, those definitions are used for generating service and process templates. Finally, complete processes are created using the templates. After those three steps, TPCM the execution of B2B interactions based on proper B2B standards.

XMI representation of RosettaNet PIPs

The example RosettaNet PIP of Figure 1 can be represented in XMI as shown in Figure 11. The figure skips some details in XMI definitions and shows only important XMI tags for the description of the PIP. Mainly, the XMI description consists of two parts: header and content. Header part provides general information about the contents of the XMI document and XMI version that is being used. The content part contains a state diagram that describes the states (activities) and the transitions between the states. XMI uses identification codes for all objects defined in it. The identification code is defined using the *xmi.id* tag. The states are

labeled S.1, S.2, S.3, and so on in the figure. Similarly, the transitions between those states are labeled T.1, T.2, T.3, and so on.

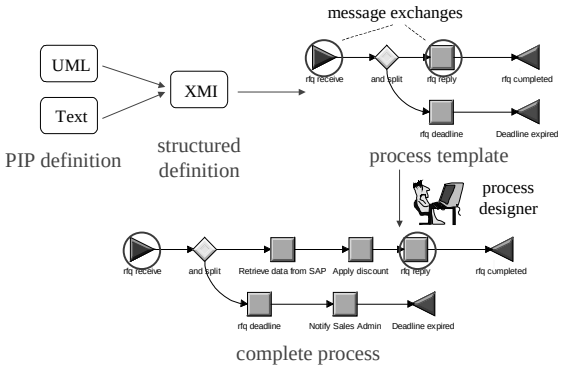

Figure 10 – Generation of a complete process from a PIP

```
File="RequestQuote.xml" Namespace="RequestQuote";
<XMI version="1.1" xmlns:UML="org.omg/UML1.3">
  <XMI.header>
            …
  </XMI.header>
  <XMI.content>
  <Behavioral_Elements.State_Machines.StateMachine xmi.id="PIP.001">
    <Foundation.Core.ModelElement.name>
     Quote Request State Activity Model
    </Foundation.Core.ModelElement.name>
    <Foundation.Core.ModelElement.visibility xmi.value="public"/>
    <Behavioral_Elements.State_Machines.StateMachine.top>
    <!-- Define Start state -->
    <Behavioral_Elements.State_Machines.Simplestate xmi.id="S.1">
    <Behavioral_Elements.State_Machines.Statevertex.outgoing>
    <Behavioral_Elements.State_Machines.Transition xmi.idref="T.1"/>
    </Behavioral_Elements.State_Machines.Statevertex.outgoing>
    <!-- Define other states -->
            …
    <!-- Define transitions between states -->
    <!--Transition T.1: from Start to Request Quote  -->
    <Behavioral_Elements.State_Machines.Transition xmi.id="T.1">
    <Behavioral_Elements.State_Machines.Transition.source>
    <Behavioral_Elements.State_Machines.Simplestate xmi.idref="S.1">
    </Behavioral_Elements.State_Machines.Transition.source>
    <Behavioral_Elements.State_Machines.Transition.target>
    <Behavioral_Elements.State_Machines.Simplestate xmi.idref="S.2">
    </Behavioral_Elements.State_Machines.Transition.target>
    </Behavioral_Elements.State_Machines.Transition>
    <!-- Define other transitions  -->
            …
    </Behavioral_Elements.State_Machines.StateMachine>
  </XMI.content>
</XMI>
```

Figure 11 - XMI description of the RosettaNet PIP that is shown in Figure 1

Process template generation from XMI definitions

Most WfMSs, including HPPM, store the process flow using state diagrams. Therefore, it is very easy to convert the XMI description of a conversational standard into a process flow description of a WfML, such as HPPM. An HPPM process is stored as a collection of XML documents and a graphical layout file. The XML documents contain the *Process Map*, which describes the flow of the process, and the services and resources that are involved in the process. The graphical layout file describes the locations of process nodes and the arcs (links) on a 2-dimensional plane so that HPPM's process definer can display a graphical flow diagram of the process to the users. The diagrams shown in Figures 3 and 4 are examples of the graphical flow diagram.

8.3 Creation of processes using the process templates and service library

In this section, we explain the creation of a process using our solution on an example. Assume that you want to create a new business process in your organization for Order Management, i.e. the process manages the quote request, order submission, and query of the order status. RosettaNet provides three different PIPs for those three steps of Order Management. Those PIPs are: **PIP 3A1 Request Quote** (submits a quote request and receives the response from a trade partner), **PIP 3A4 Manage PO** (submits, updates, or cancels a purchase order), and **PIP 3A5 Query Order Status** (keeps track of a previously submitted order's status).

The process templates for these PIPs can be generated as explained earlier. The process templates and individual B2B services are stored in a repository, from which they can be retrieved by a user and inserted into a new or existing process definition. Figure 12 shows an example process that manages quote request, purchase order submission, and order status query. A developer can start the design of a new process by pulling out PIP 3A1 template and inserting it at the beginning of the new process definition. Then, the templates for the PIPs 3A4 and 3A5 can be appended after the first template. Minor corrections may be needed to make sure that the data items of successive process templates are compatible with each other. It may also be necessary to make some small modifications on the process definition, such as adding more nodes to add more functionality to the new process. For example, the user might want to store the received quote in a database. He/she can do that by simply inserting a node after the template of PIP 3A1 in order to store the quote in a database. The templates are pre-cooked of processes, which can be added together and enhanced with more nodes to achieve more functionality.

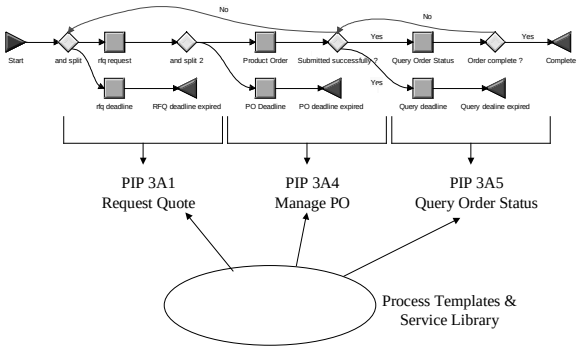

Figure 12 – An example process built from process templates of multiple PIPs

8.4 Enhancement of existing internal processes with B2B interaction capability

So far, we have concentrated on automatic generation of new processes that support B2B interaction standards: when the conversational logic is provided in XMI format, an HPPM process template that supports the standard can be generated automatically. It is very likely that many organizations might already have internal business processes, which have to be enhanced so that they could interact with the trade partners of those organizations. The service library can be used to plug in B2B interaction services into an existing process. The service templates handle the interaction points with the trade partners using an industry standard, such as RosettaNet. The existing processes do not have to be modified. They only need to be enhanced by inserting the service templates at the nodes where the interactions with trade partners take place. We skip the example due to space limitations.

8.5 Support for multiple B2B standards

We have focused on the integration of WfMS with RosettaNet PIPs so far. The most important step in that integration is the generation of templates in three detail levels: process, service, and XML document formats. Templates for CBL, EDI, and other B2B interaction standards can be generated from the XMI descriptions of the message flow and contents, as explained in sections 8.1 and 8.2. Once the templates are stored in the template library, the users can easily pick those templates and plug them into the process flow diagrams as

shown in section 8.3. We skip the examples for CBL and EDI due to space limitations, and also because the methodology is the same as the one described throughout section 8.

9. Related Work

B2B interaction standards are explained in section 2. In this section, we summarize other related work in two categories: research and commercial products.

9.1 Related Research

Most of the related research was done in the field of inter-organizational workflows. One of the first contributions comes from Van Der Aalst [Vanderaa98]. In that paper, the author presents taxonomy of possible interaction types. Then, the paper concentrates on one particular type: loosely coupled interaction, which occurs when two or more parts of a process can concurrently run on two WfMSs on different organizations.

An abstract definition of inter-enterprise workflow systems was given in [Gal99], but practical issues, such as message exchange, data mapping, and B2B standards, are not addressed at all. The paper simply extends a common workflow model to include entry and exit points to allow inter-enterprise communication.

WISE project [Alonso99a, Alonso99b] aims at developing an infrastructure for B2B e-commerce. The WISE architecture includes a component for the specification of virtual business processes, a component for their enactment, a component for process monitoring and analysis, and finally a component that manages context-aware communication among process participants.

CrossFlow [Crossflow00] is a recently started Esprit project aiming at the definition of an infrastructure for inter-organizational workflows. CrossFlow assumes a centralized description of the process that is to be executed. It is translated into the workflow languages of the participating WfMSs. Suitable gateway components, configured according to the business agreements that have been reached among participating organizations, manage the interactions among the WfMSs.

The approach of [Klinge98], also developed within CrossFlow, focuses on a particular form of workflow interaction, where an organization refers to another organization for the execution of part of its business process (subcontracting, in the terminology of [vanderaa98]). An organization acts as a service provider,

receives service requests and input data, carries out the requested process (possibly by periodically notifying progresses in process execution), and eventually completes the service, returning output data to the calling organization.

Eder and Panagos [Eder99] propose an event-based infrastructure to support cooperative workflows. In their approach, workflow participants, workflow engines, and workflow administrators can subscribe to several types of events, possibly published by different workflow engines. By subscribing to events, a workflow engine becomes aware of advancements in the execution of processes enacted by other engines, and can use this information to trigger the execution of activities in its own processes.

CMI project at MCC [Georgako99] focuses on methods and tools for defining processes that compose *services* provided by different companies. The authors present an advanced workflow model with several new primitives for managing coordination among services. One of the main features of the model is that it allows, for each service, the definition of application-specific states (e.g., *loan requested* or *loan approved* for a loan management service) and operations (e.g., *cancel loan request*). When the designer specifies a process by composing services, she can define control flow conditions based on the (application-specific) states of component services, and can specify when (application-specific) operations should be invoked on the component service.

WfMC's interoperability standard [Wfmc00] concentrates on chained and nested workflows, where the completion of one workflow triggers the execution of another one at a different organization, or one workflow initiates the execution of another one at a different organization.

While all these approaches are very interesting and do support interactions among workflows executed in different organizations, they do not deal with the problems of integrating B2B interaction standards with the internal processes and enabling fast, template-driven generation of processes and services that can interact according to such standards.

9.2 Commercial Products

There exists many products in the market that claim to support RosettaNet and other B2B interaction standards. Most of those products do not provide anything more than simple tools for sending and receiving

XML messages, and very few of them address the problem of integrating B2B interaction standards with internal workflows. In this section, we list a few products that actually provide some level of support for the standards, rather than simply sending and receiving XML messages. Unfortunately, the discussion of commercial products is based on user manuals and few white papers only, because there are not any published papers describing details about those products.

WebMethods [Webmet00] claims to support RosettaNet PIPs, but it does not provide service library or process templates. It only includes a component that enforces the XML message exchange specifications of PIPs, such as preparing, submitting, receiving, and parsing XML documents, and waiting for acknowledgment and response messages. The actual implementation of the conversational logic of PIPs still requires considerable manual effort.

BlueStone's Total-e-B2B product [Bluestone00] provides tools to develop, deploy, and manage B2B transactions. It supports many standards, such as XML, EDI, J2EE, etc. However, it does not support any standard that defines B2B conversations, such as CBL and RosettaNet.

Vitria's BusinessWare product [Vitria00] has a RosettaNet centric version that is claimed to support currently published PIPs. It runs on top of Vitria's BusinessWare suite, and provides basic functionality that is required to carry out B2B interactions based on RosettaNet PIP definitions. It performs data mapping from DUNS, UNSPSC, and GTIN standards, which are data standards accepted by RossettaNet. However, it does not provide integration with any internal workflow management systems.

BEA's WebLogic {Bea00] Collaborate Enabler for RosettaNet provides a "Process Integrator" that manages the exchange of XML messages with trade partners. Moreover, WebLogic provides templates for currently published RosettaNet PIPs. Unfortunately, we do not know whether it is possible to automatically generate templates for new PIP definitions. Our understanding, based on the product manuals, is that new templates are created manually from PIP definitions and provided to the customers in a template library. Since there are not any research publications about this product, we cannot provide further information. One of the main contributions of our paper is that we explain the complete methodology for automatically generating and using process and service templates that comply with B2B standards.

10. Conclusion

Our solution for integrating WfMSs with B2B integration standards, which consists of automatic B2B service and process template generation, the use of TPCM, the repository of B2B services and process templates provides the following advantages:

1. It allows easy and fast adoption of B2B interaction standards. Service and process templates can be automatically generated from structured definitions of the standards. Those templates are stored in a repository and used by process designers to easily enhance the business processes with B2B interaction capability. The templates speed up both development of new B2B capable processes, and the enhancement of existing processes so that they can carry out B2B interactions. Moreover, service templates from different B2B standards can be plugged into the same workflow process when it is necessary to interact with multiple trade partners that use different B2B standards.
2. It allows the users to design processes without having to know details about the interaction standards. TPCM takes care of choosing which standard to use, based on the preferred standard of the trade partner, and handles the details of sending/receiving messages, waiting for responses, etc.
3. Changes in the standards can be applied to existing processes with minimal effort. For example, a change in the time limit for waiting for an acknowledgment message can be applied by a small modification in the TPCM parameters. Similarly, a change in an individual interaction type can be applied by replacing the definition of a B2B service in the service library. Moreover, a change in the overall definition of a B2B conversation can be applied by automatically re-generating the process template from the new structured definition of the corresponding standard.

These benefits lead to business processes that can be designed quickly and easily, and require very little management effort since they are (to a great extent) transparent to changes in the standards, and even to the choice of standard being used by the trade partner. The proposed solution concentrates on integrating HPPM processes with RosettaNet PIPs as an example, but it can be easily extended to support other WfMSs and B2B interaction standards.

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