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The Role of Messaging in Collaborative Business Processes

Shazia Sadiq and Maria Orlowsak
The University of Queensland, School of Info. Technology & Electrical Eng., St. Lucia, Brisbane, Australia

Wasim Sadiq
SAP Research, Brisbane, Australia

ABSTRACT
Business process management technologies are considered as one of the key success stories in providing process control and addressing complex integration requirements. However, the expectation of what this technology must deliver is a moving target. What was true for workflow systems is no longer acceptable in the dynamic and cross organizational requirements for management of collaborative processes. Whereas the success of coordinative processes depends upon the conformance to the prescribed control flow, the success of the collaborative process depends upon the ability to detect and react to changing conditions. In this paper we highlight the differences between the well known coordinative and emerging collaborative processes and present key distinguishing characteristics. We further deliberate on the widely established role of messaging as an enabling technology for inter and intra process communication. Acknowledging the role of messaging, and the distinct requirements posed by collaborative processes, we question the appropriateness of current control flow driven approaches and propose an alternative mode of thought for addressing the modeling and execution of collaborative business processes. This paper is not intended to present a complete solution of the alternative approach, but to identify it as a viable research direction and a potentially more appropriate approach.

INTRODUCTION
Collaborative business process technologies are firmly positioned as an industry hot spot due to the increasing demands from the business sector for effective management of outsourced business activities and ability to control cross-enterprise processes. It is well known that this demand brings with it complex integration requirements that span interoperability across multi-platform systems, to semantic differences in business terminology.

Historically speaking, process enablement has been a driver for enterprise systems for a significant period of time. The pitfalls of functional over-specialization and lack of overall process control has been well documented. Technology response to this business demand was met with a suite of technologies, ranging from groupware and office automation, to workflow systems, and more currently business process management technologies.

In Figure 1, we show building blocks of process-enabled enterprise systems. Just as the DBMS provided a means of abstracting application logic from data logic, the WFMS provided a means of abstracting coordinative process logic from application logic. Every generation has provided additional functionality through supporting systems. Although, workflow technology has delivered a great deal of productivity improvements, it has been mainly for pre-defined static and repetitive business processes, that required basic level of coordination between human performers and some application components.

More recently business process management (BPM) has been used as a broader term to reflect the fact that a business process may or may not involve human participants and may also cross organizational boundaries. There is currently a wide spread interest in academia and industry on business process management technologies, especially in light of emerging paradigms surrounding web services and their application in dynamic business process composition. There are a number of standards and initiatives in this regard generally focused on the problem of B2B process integration [3].

Key guiding principles behind process-enabled systems include:

- A clear separation of Process, Business, Data, and Presentation aspects of enterprise systems with minimal overlap.
- Status, instance, and context management are an intrinsic part of overall process management architecture.
- Process Modeling is an integral and essential part of systems development and deployment lifecycle.
- Business processes are primarily captured through modeling and business logic is primarily implemented through coding of application components.
- Application components have minimal direct awareness of one another and also have minimal direct awareness of "where and how" they are being utilized in BPM layer.
- BPM takes the primary responsibility to achieve business objectives through configuration, coordination, collaboration, and integration of application components.
- Clear mapping between design time conceptual modeling environment to capture 'real life' business processes and runtime execution environment supported by IT infrastructure.

Figure 1. Building Blocks of Process-Enabled Enterprise Systems

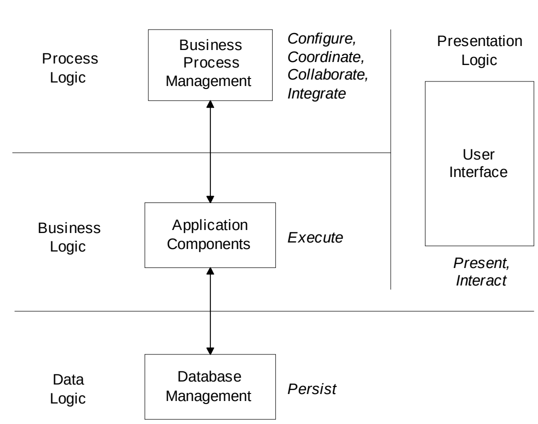
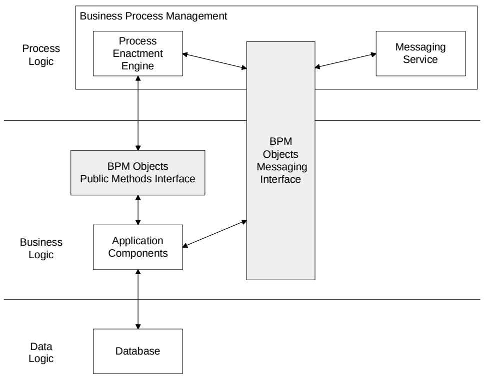
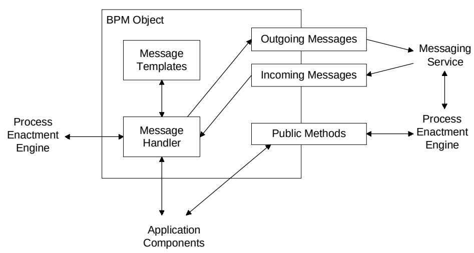


Figure 2.BPM Objects



(a) Role of a BPM Object



(b) Interfaces for BPM Object

- Similar BPM principles are applied in achieving intra-application, application to application, system to system, as well as business to business integration

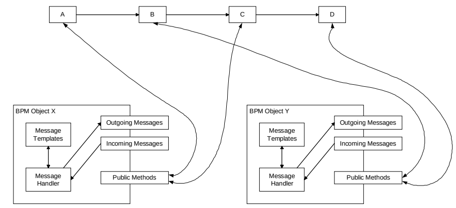
ROLE OF MESSAGING TECHNOLOGIES IN BPM

Messaging technologies play a key role in current BPM platforms. This role is primarily that of facilitating interactions between partner organizations running potentially heterogeneous systems. Message oriented middleware [15] is known to tackle some key issues of cross enterprise data exchange, without violating individual system autonomy. We explain this further by introducing a BPM architecture that utilizes the concept of a **BPM Object.** In this architecture, application components are exposed as BPM objects, which may have public method interface and/or messaging interface. This concept allows us to use the same BPM Object as an interaction bridge between application components and BPM technologies whether we want to make method calls to application components or let messages derive the interaction. Figure 2(a) illustrates the position of BPM objects in the overall process enabled enterprise system, and Figure 2(b) shows a more detailed view of the BPM object.

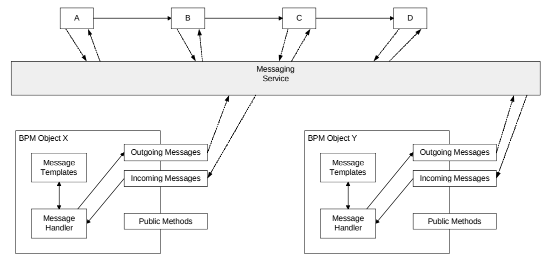
As with any common representation model to which multiple systems conform, communication through a common messaging service to multiple application components reduces the need for dealing with multiple public method calls (Figure 3). Recent developments in Service-Oriented Architectures (SOA) [1], [14] also build upon message based service interactions.

In this paper, we assume the availability of a messaging service as described above for BPM objects, to establish communication between application components. It is irrespective of whether the communication takes place between application components within the same organization (A2A) or across organizations (B2B).

Figure 3. Invocation of BPM Objects



(a) Through Public Method Interface



(b) Through Messaging Interface

COLLABORATIVE BUSINESS PROCESSES

There have been significant efforts both from research and industry on the issue of business process modeling; as a result business process modeling has acquired rather diverse interpretations. In this paper we only consider only deployable process models. In the sections below, we present two approaches for specification of deployable collaborative processes. Both are presented under the assumption that a messaging service is available for facilitating interactions between application components within as well as across an enterprise.

Consider first the following scenario which intends to distinguish a *collaborative* process as distinct from a traditional *coordinative* process.

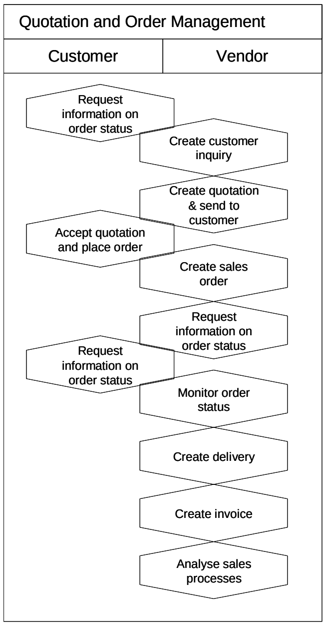
A Quotation and Order Management process typically supported by Customer Relationship Management (CRM) solutions is governed by the terms and conditions of trade as agreed by trading partners. These terms and conditions may, and do apply, to any phase of the process, from inquiry, quotation, and sales order processing, to delivery, billing and analysis. For example, it may be agreed that response time for a request for quotation (RFQ) will be provided within 24 hours, or that price variations from the agreed conditions beyond a certain threshold have to be approved by a manager role and so on. Figure 4 shows the scenario map of quotation and order management from the vendor perspective [16]. Experience indicates that such collaborative processes may be encountered by a number of unpredictable and asynchronous events. These events may in turn require one or more steps of the process to be dynamically adapted to the changing conditions.

Such events are inevitable when ever multiple partners are engaged in a collaborative process. Thus whereas the success of coordinative processes depends upon the conformance to the prescribed control flow, the success of the collaborative process depends upon the ability to adapt to changing conditions.

In summary, we present below key characteristics of the collaborative process:

- The process progress is **Event Driven** rather than control flow driven. The complete anticipation of these events is unlikely.
- This further indicates the presence of multiple **Asynchronous Activities** which are independent to a large extent, but outcomes of which can influence the overall process
- **Multiple Participants** will be involved in a collaborative process. This does not introduce conceptual complexities since there can be

Figure 4. Collaborative Process: Quotation and Order Management



Examples of dynamic, asynchronous events impacting on the process can be:during sales order processing, a particular item may be cancelled impacting on the subsequent delivery and billing phases; during outbound delivery processing, transportation factors may impact on agreed delivery time, and billing process may be adjusted accordingly;customer may want to accept the order partially and place an order of selected items while still negotiating with the vendor on remaining items;customer may monitor and inquire about the order status at any time and change the order quantities at any time within vendor specified constraints.

multiple performers and/or multiple applications in an inter-enterprise workflow as well. However, it does introduce a great deal of complexity due to system heterogeneity, which is a significant but different problem. Open standards can play a significant role in overcoming this aspect of the complexity.

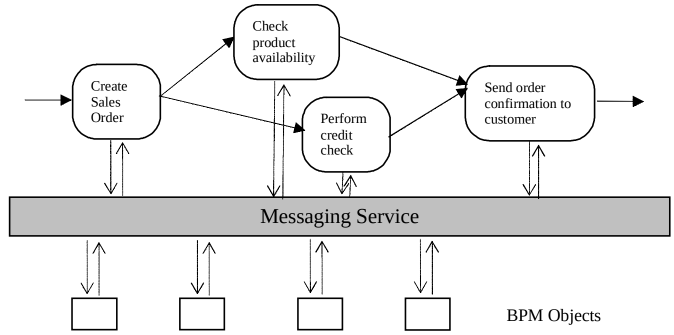
- The interactions between multiple participants can translate into rather complex rules and are well beyond the typical sequence, parallel and choice constructs found in workflow languages. These **Complex Interactions** include multiple dimensions of time, data, resources and events.

In business scenarios with characteristics as above, the conventional coordinative or control-flow driven modeling approach is not well positioned. In spite of this clear distinction, much of the ongoing work on collaborative business process technologies is inspired by workflow-like modeling approaches. We believe there is a strong need to extend the current "Process Driven Messaging" approach to "Message Driven Processes" approach for effective management of collaborative business processes.

Process Driven Messaging

Process enactment systems traditionally rely on the control flow defined within the process model, which triggers the invocation of the underlying application component. Even though the interaction between the application component and the process engine may take place through a messaging protocol instead of a method call, the order of application execution is driven by the process.

Figure 5. Process Driven Messaging



Consider for example (a static version of) the sales order processing phase within the overall quotation and order management process [(extract from)help.sap.com CRM 4.0]. Figure 5 illustrates that such a process may be managed by a traditional process enactment systems or workflow management system (WfMS), where-in, various business activities (create sales order, perform credit check etc.) are scheduled and consequently executed under the control of the WfMS. That is, the messages exchanged between the workflow engine and the BPM objects (and corresponding application components) are directly controlled by the WfMS.

This approach has been highly successful in coordinative processes. The ability to abstract the process logic, and then utilize it to drive the business activities is a key feature of workflow systems. This approach however, becomes arguable for collaborative processes due to their specific characteristics as identified above. This point is further explained in the next section.

Message Driven Processes

In collaborative processes, it is expected that independent BPM objects both within and across organizational boundaries, will be capable of detecting the events which dictate subsequent process flow. These events can be many and can arise at any time during the overall process and cannot be anticipated by related or dependent BPM objects. Thus in a message driven process, the BPM object detecting an event, would need to communicate relevant data pertaining to the event to the process enforcement system. It is natural to contemplate that this would take the form of message passing.

The critical factor is that the process enforcement system is empowered with sufficient intelligence, so that the appropriate action can be taken when a particular message arrives. This action basically constitutes communicating the relevant data to the right process participant (another BPM object, an application component, a trading partner, or even a workflow performer) at the right time. This onward communication can also be assumed to take place through a messaging protocol. Thus, an incoming message representing a process event, is interpreted and evaluated against given conditions, and an appropriate outgoing message is created. We refer to such handling of messages as message ***harmonization***.

Modeling a collaborative process through the messages that are exchanged rather than through a rigid control flow between its activities is a significantly different albeit more natural way of capturing collaborative processes. Thus business activity takes place within application components, however, the context for the business activity is provided by message harmonization. How the business activity deals with the message is not the question, instead capturing which business activity may need to be informed about a particular event, and when, is the question at hand.

At a minimum, providing message harmonization entails specification of the message types that will be exchanged and the conditions under which this exchange will take place. Investigating the specification framework for harmonized messaging is a challenging and interesting research question. It holds challenges both for the modeling environment, as well as the execution framework.

We believe that such a Harmonized Messaging Management System (HMMS) holds the potential to overcome a large number of difficulties associated with business process management and enterprise application integration by providing a unified framework for the facilitation of diverse exchange patterns.

RELATED WORK

Although collaborative processes that utilize messaging as the underlying technology infrastructure is well recognized as a technology direction for current BPM especially in the B2B sector, we could not find studies in the literature that address directly the foundation aspects of conceptual modeling of such processes. Most of the work is mostly a derivative of workflow modeling, extended with a few constructs to partially overcome the differences. We believe that a fundamentally different modeling approach will be required to satisfactorily meet the specific requirements of collaborative processes distinguished by the four inherent characteristics identified previously.

However, a number of diverse technologies can play a role in the approach to provide harmonized messaging to facilitate complex interactions in collaborative business processes. Where as a comprehensive survey of these technologies cannot be accommodated in this paper, we present below a short description of what we believe to be technologies relevant to this proposal.

Integration technologies such as brokers, application adapters, portals and messaging are fundamental elements of a collaborative business process environment. For this wide-spread enterprise application integration (EAI) and/or business to business (B2B) integration to become a reality, we need common architectures and open standards to support it. Current developments have built upon the lessons learnt from substantial work accomplished in distributed computing such as CORBA and DCOM. B2B protocols attempt to establish a common language between businesses, so that collaborations (which occur between two business partners) can take place without the need for pair-wise negotiation of integration. Such protocols are message centric by definition, describing the formal message exchange necessary for an interaction to take place between two business partners. B2B protocols have been an active area of research [3] with two of the predominant solutions in this area being RosettaNet *www.rosettanet.org* and ebXML *www.ebxml.org*.

The research on ***Workflow languages*** provides both the foundation, and occasionally the bias towards meeting advanced process requirements. Several aspects of a workflow model including control flow, data flow, participant assignment, exception handling, temporal constraints, transactional, messaging have been studied [6]. Control flow is considered to be the foundation for capturing other aspects and as such, control flow modeling and verification has been an active area of research [9]. Efforts to identify advanced workflow constructs to address specific process requirements have been undertaken [www.workflowpatterns.com].

In the area of collaborative business processes, the work is generally presented in the context of extending web service functionality at the level which is often referred to as the orchestration or choreography layer of the web services stack [12]. These extensions are aimed at capturing more meaningful semantics than simply service invocations, enabling the modelling and implementation of business processes in the web service context. Prominent initiatives in this area include WSCI, and BPEL4WS.

Complex event processing is a term coined by [8] for approaches identifying patterns in event-based systems. Examples of such systems can range from low-level network monitoring (for example intruder detection) up to high-level financial transaction system (for example monitoring stock trade systems).

Event algebras have been published in different contexts, one of the most significant areas is the research into Active Database Management Systems [13]. These build upon an event-condition-action pattern where the event detected can be a pattern of other events [4].

We see the relevance of lessons learnt from event based systems in general and complex event processing in specific to the design of a message driven framework for collaborative processes. In particular we note a conceptual overlap in the notion of event causalities and long running correlated message exchanges.

An essential component of the next generation of distributed architectures is ***message oriented middleware*** (MOM). MOM has gained increasing deployment and already delivered great benefits for communication between disparate systems, and as a grass roots component of the web services stack [7]. In spite of the move from propriety networks to open standards, the fundamental functionality of MOM has not changed substantially. Looking at currently available solutions, we see that the focus of MOM has been primarily to deliver Security (authorization, digital signatures, non-repudiation); Reliability and Serializability (guaranteed delivery in the proper order); and Scalability (high volume and speed). The technology is driven by mainly two dispatch models.

One is point to point, where message exchange takes place between a sender and one recipient. This is often based on queuing methods, such as the IBM's WebSphere MQ series (*http://www-3.ibm.com/software/ts/mqseries/*). A second dispatch model is publish-subscribe, which is used for content dissemination to multiple recipients or subscribers. Some essential enhancements to basic messaging technology have been proposed, see e.g. Elvin [1], Gryphon [11], and READY [5].

CONCLUSION AND OUTLOOK

In this paper we have identified four characteristics of collaborative business processes, namely *event driven*, involving *asynchronous activity* execution, *multiple partners* and their engagement in *complex interactions*. These characteristics distinguish collaborative processes, from the better known coordinative processes, for which successful technology solutions already exist.

In light of these distinct characteristics, we believe it is important to think beyond workflow-like languages for the modeling of collaborative business processes. The message driven approach we identified in this paper, seems to be an attractive alternative. A system to manage this message exchange, and provide a unified framework to facilitate the diverse and complex interactions found in this domain can overcome some of the notorious difficulties associated with managing collaborative business processes.

The ground work to identify the core functionality of the harmonized messaging management system is underway [10]. While we pursue the critical aspects of modeling the complex message exchange as well as providing a scalable execution framework, we would like to present these questions as challenging open research questions.

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