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ABSTRACT

Studies show that the physical implementation of an interorganizational business process or system can be a major source of operational problems and reduced business benefits. Better process modeling has been advocated as a solution. Although powerful modeling tools exist, current practice often gives short-shrift to documenting the physical implementation details that can create or exacerbate such problems. In this paper we describe the modeling approach we devised for the interorganizational business processes and systems we observe in our ongoing fieldwork. Our approach involves using allowable extensions to a popular modeling notation (BPMN), although other modeling tools would work equally well. We illustrate the benefit of our approach in the case of the Internet Payment Platform, a pilot project of the United States Department of the Treasury.

Keywords

Interorganizational systems, IOS, business process modeling, BPMN

INTRODUCTION

Numerous studies show that the benefits of interorganizational systems (IOS) depend on implementation decisions related to system integration (Angeles, et al., 1998; Barua et al., 2004; Berente and Vandensbosch, 2004; Hart and Estrin, 1991; Iacovou, et al., 1995; Truman, 2000), process changes (Chatfield and Yetton, 2000), and IT infrastructures (Barua et al, 2004; Clark and Stoddard, 1996; Chatfield and Yetton, 2000; Truman, 2000). Unfortunately, IOS do not always yield the expected benefits (Riggins and Mukhopadhyay 1994). One plausible reason for disappointing results could be the failure of IOS designers to consider their business partners' systems, processes and infrastructures. Consequently, better process modeling might improve the effectiveness of IOS design efforts:

> " . . . the way in which a firm's trading partners implement and use the system can have a direct impact on how the initiating firm realizes benefits from the system (p. 42). … By formally modeling the processes at the 'external' entity, areas of change resulting in mutual benefit may be more easily recognized." (Riggins and Mukhopadhyay 1994 p. 54)

This paper describes the modeling approach we developed to help us analyze the problems and improvement opportunities in the interorganizational business processes we are studying. The approach we took involved making allowable extensions to a

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popular modeling notation, Business Process Modeling Notation (BPMN). We chose BPMN because its designers have the stated intention of developing a tool that can be used to generate executable software code for interorganizational business processes. However, our general approach can be followed by modelers using any number of other modeling notations, including UML and traditional process flowcharting. Our BPMN extension (called BPMNe) can be used to model both as-is and to-be processes as they evolve over time owing to changing business requirements. Therefore, it is particularly useful for showing how implemented processes can diverge from the ideal processes envisioned by designers, resulting in what we call design and implementation gaps.

We first discuss business process modeling and the need to represent physical implementation details. Then we illustrate our modeling approach for a specific IOS. The final section discusses how our approach can contribute to IOS implementation success.

MODELING INTERORGANIZATIONAL BUSINESS PROCESSES

The goals of business process modeling are to diagnose problems with existing business processes, to redesign new processes, and to facilitate communication between process participants and system developers. Process models can be described as logical or physical (DeMarco 1979), and they can depict four different views of a business process—functional, behavioural, organizational, or informational (Curtis et al. 1992). A physical model is defined as "implementation-dependent", whereas a logical model is "implementation-independent; pertaining to the underlying policy rather than to any way of effecting that policy." (DeMarco 1979 p. 343; see also Ould 1995). The functional view represents *what* processes are performed. The behavioural view shows *when* process activities are performed and some aspects of *how* (e.g., conditional tests). The organizational view depicts *where* a process is performed and by *whom*, including physical communication mechanisms and storage locations. The informational view represents the data produced or manipulated by a process.

Modeling proponents generally advocate starting with a physical model of the existing business processes and then stripping out the physical details of who, what, when, where, and why, in order to build models that can be used for process redesign and system development (Ould 1995). In practice, process and system designers often skip the physical modeling step. Unfortunately, physical implementations often differ from idealized logical processes in ways that jeopardize the achievement of designers' objectives (DeSanctis and Scott Poole 1994). For example, when a partner re-keys data, time is wasted and errors increase. When a policy or law requires that a paper copy of an electronic document (such as a purchase order) be created, signed, and mailed, friction is introduced into an otherwise smooth interorganizational process. Detailed models of physical implementations before and after interorganizational process redesign and system implementation can help modelers diagnose problems (such as redundancies or workarounds) and design more effective solutions.

Business Process Evolution and Implementation Gaps

Business processes change over time because of design decisions and natural evolution. In Figure 1 below, the filled circles represent a process at different points in time, i.e., the then-current "as-is" process. The arrows represent the evolution of a process between two points in time. Each clear circle represents a planned business process – the "to-be" – as envisaged at a specific point in time. For example, in Figure 1 the clear circle labelled t_1 represents the to-be process for time t_1 as visualized at time t_0. However, between times t_0 and t_1 the process implementation evolves and adapts to its environment, resulting in an as-is process at t_1 that varies from the planned to-be process. The difference is shown as an *implementation gap* in Figure 1. Process evolution and the resulting implementation gap can be either a hindrance to an organization or a useful adaptation (Brown and Eisenhardt 1998; Haeckel 1999). It is helpful to accurately document the changes, in order to address the negative aspects of the implementation gap and to reinforce the positive aspects. Although deliberate process improvement interventions are shown at times t_0 and t_2, process evolution still occurs between all description points, e.g., between t_1 and t_2, as the process-in-use is adapted to meet changing internal and external demands.

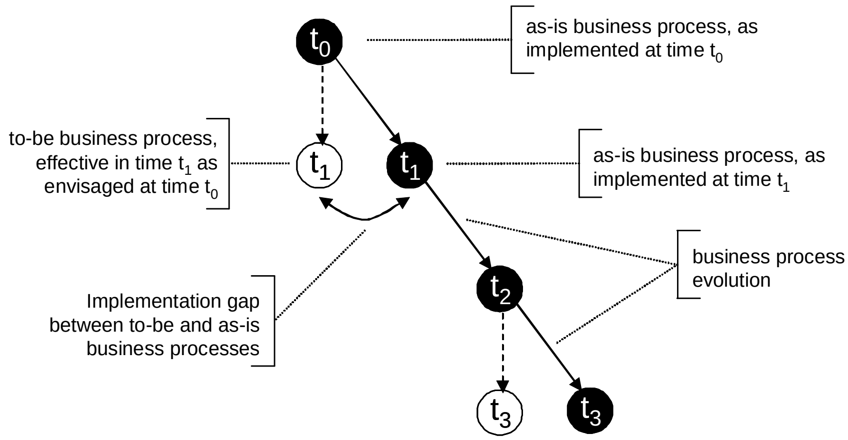

Figure 1. Business process evolution and implementation gaps.

Our Modeling Approach

Following Ould (1995 p.164) we propose that the redesign of IOS processes should start with preparing an as-is physical process model. Physical artifacts can then be stripped out to produce a logical as-is representation. Once a better way of implementing that process is identified, a logical to-be representation can be made, followed by preparation of a new to-be physical process model. Ould recommends that the design team should move iteratively back and forth between logical and physical models (p. 164). Although textbooks generally advocate the preparation of to-be *logical* representations for sound systems design, little mention is made of the benefits of to-be *physical* models for identifying redundancies, workarounds and other barriers to process effectiveness, particularly *after* the new process has been implemented.

To capture the physical elements that can derail interorganizational systems we developed a set of "allowable" extensions (BPMNe) to a popular business process modeling notation (BPMN). We could equally have started with UML or traditional process flowcharts. Thus our approach should not be construed as a critique of BPMN per se, but rather as a set of guidelines that BPMN modelers (or other tool users) should follow for the particular use case of interorganizational system diagnosis and design. BPMN was developed by the Business Process Management Initiative (BPMI) specifically for the purpose of modeling both the logical and physical aspects of intra- and inter-organizational business processes (Harmon 2003 p. 278). BPMI promotes the development of standards for process design, the translation of process designs into executable language, and the construction of automated systems.

Design and Implementation Gaps

Figure 2 shows three levels of process description: logical, physical, and extended-physical. At the logical level the focus is on *what* is to be done. The physical level shows the process as it is or will be implemented, using standard BPMN notation. The extended-physical representation, BPMNe, adds further implementation-specific detail to BPMN. As noted above, much system development work in practice focuses overly on to-be logical representation, giving insufficient weight to current, planned, and post-hoc physical representations. When system design does not adequately address the process elements that affect implementation, a design gap may result. This design gap can be illuminated by comparing an as-is extended physical process representation with a to-be extended physical process representation. Consistent with Figure 1, the implementation gap is shown by the difference between the t_{n+1} to-be extended physical representation (as envisaged at time t_n) and the t_{n+1} as-is extended physical process diagram. Process evolution accounts for the difference between the as-is process at time t_n and at time t_{n+1} and results from designed changes as well as emergent, local changes arising from the process-in-use. The process improvement cycle can then begin again in Figure 1 by replacing the as-is extended physical representation made at t_n with that made at t_{n+1}.

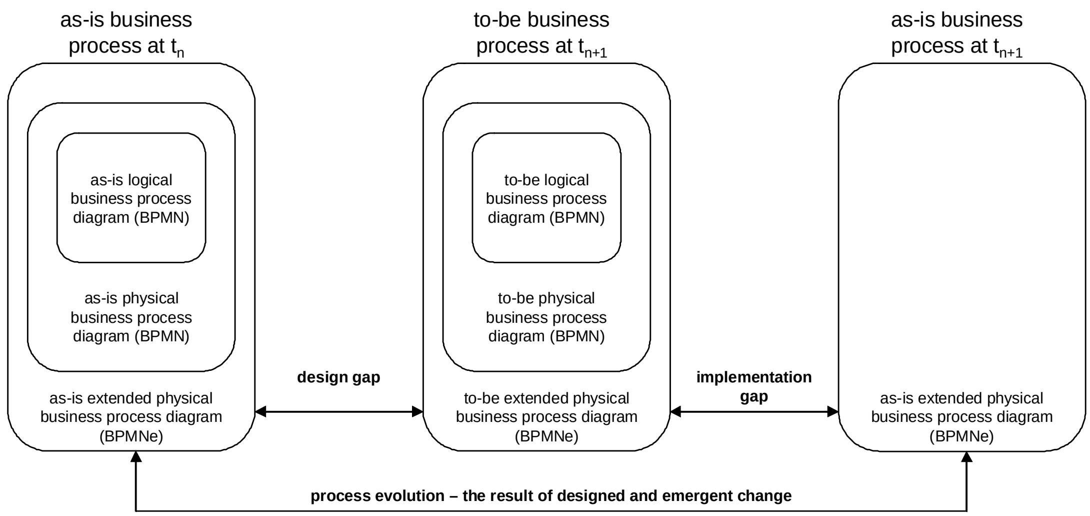

Figure 2. Business process representations.

In the next section of this paper we illustrate our modeling approach with an actual example from our own fieldwork. All diagrams were created for the purpose of this paper.

METHODOLOGY

The IOS example described below is based on a case study of the Internet Payment Platform (IPP) 2003-2004 pilot test by the United States Department of the Treasury and three federal agencies. Interviews (ranging in length from 30 minutes to 2 hours) were conducted with more than 20 individuals employed by participating organizations – including the software vendor, managers in the Financial Management Service of the United States Department of the Treasury and the Federal Reserve Bank, and purchasing, finance, and IT managers at the three participating agencies. We also interviewed personnel at selected participating suppliers and analyzed the survey data collected from participants by pilot sponsors at the conclusion of the pilot. All interviews were taped and professionally transcribed. To triangulate on key facts and perspectives, various archival documents (such as the *Concept of Operations* proposal) were examined. Based on the interviews and archival documents, we prepared a narrative description of the IPP system (a portion of which, the invoice process, is provided in Exhibit 1, below) and asked key informants to verify that the details were correct. This process took several rounds of revision before our informants agreed that the narrative was correct and complete. We then prepared the BPMN and BPMNe diagrams using Microsoft Visio and Process Modeler, a Visio add-in for BPMN from ITpearls Ltd.

TWO VIEWS OF IPP

In this section, we describe the invoice process portion of the Internet Payment Platform (IPP), an e-procurement system that was piloted by the United States Department of the Treasury in 2003-2004. The system enabled from government agencies (e.g., the Bureau of Engraving and Printing, or BEP) to send electronic purchase orders to their suppliers, for suppliers to convert (or “flip”) those POs into invoices, and for agencies to pay those invoices electronically. A narrative description of the invoice process is given in Exhibit 1. Figures 3 and 4 depict the as-is physical invoice process of IPP, using BPMN and BPMNe respectively.

Having been notified via e-mail that a PO has been issued, a BEP supplier logs on to IPP, reads its POs on screen, and responds by providing goods or services. For reasons described in section 4.3 (below), a paper PO is also created and signed. The supplier may wait for receipt of the paper PO before beginning the process of providing the goods or services. (Different suppliers have different policies regarding whether a paper PO is required before they will provide goods or services.) Suppliers may want or need to enter BEP POs manually into their sales systems. (If so, the supplier’s sales order record duplicates the PO in the IPP database.) *After entry of POs into the sales system, suppliers’ internal processes are not shown in Figures 3 and 4.* Once the supplier provides the requested goods or services, BEP employees record receipt of those goods into BEP’s enterprise system, BEPMIS. *Receipt of services is not shown in Figures 3 and 4.* The receipt itself is not recorded in the IPP database. Once goods or services have been provided, the supplier logs on to IPP to request a PO "flip" to create an invoice that is posted to the IPP database.[2] At this point, the invoice may be viewed by both BEP and the supplier. IPP then sends the invoices to the enterprise adapter at BEP, where the invoice data is translated from XML into the IDMS database format for posting to the BEPMIS accounts payable system. The supplier invoice now resides on the supplier database, the IPP database, and BEPMIS.

Once the invoices are posted, BEPMIS performs a three-way match of invoice, PO, and receipt. We assume here that the invoices match and are posted to BEPMIS (i.e., error routines are not shown)[3]. An invoice status change record is then sent to the IPP server so, now an updated record of the supplier invoice resides on both BEPMIS and the IPP database. BEP and the supplier can view these records on the IPP database and resolve disputes (e.g., disagreements regarding the price or quantity as listed on the invoice) as required. As the status of the invoice changes, BEPMIS then extracts the changes, formats them, and transmits them for posting to the IPP database after the data has been translated to XML by the enterprise adapter. The supplier can review the status of an invoice as it moves through the payment generation process. Status can be "Pending Approval," "Scheduled for Payment," "Paid," or "Rejected."

Exhibit 1: Internet Payment Platform (IPP)—Narrative Description of the Invoice Process at the Bureau of Engraving and Printing and its Suppliers (the following description corresponds to Figures 3 and 4)

IPP Represented in BPMN

Figure 3 depicts the as-is IPP invoice process modeled with BPMN without our extensions. BPMN includes the following standard elements (BPMN, 2004), which are important for both logical and physical representations:

Flow objects

BPMN flow objects consist of events, activities, and gateways. Events are things that happen, and are represented by some version of a circle, with a flow into an activity. See "PO from BEP," which is one of the events that starts this process. Activities constitute the work performed and are represented by rounded rectangles. For example, "Receive paper PO" is one of the first activities in this process. Gateways, represented by diamond shapes, control divergence and convergence of sequence flows, such as "Respond to paper or electronic PO."

Connecting objects

Sequence flows are used to connect activities and indicate order of activities through the use of arrows. Observe the solid lines with arrowheads, such as that between "Receive e-mail from IPP" and "Log onto IPP and request PO display" in Figure 3. Message flows depict exchanges between entities. See the dashed flow lines in Figure 3 such as those to and from "Retrieve and display PO". Associations are used to associate information with flow objects such as the dotted line connecting "Packing slip" to a message flow.

Swim lanes and pools

Swim lanes and pools are used to group modeling elements into different organizational units. Swim lanes are used to represent smaller organizational units within an entity and may represent departments, functions, or servers, for example. Pools are used to represent entities - larger organizational units that are meant to be distinct from each other. In Figure 3, pools partition a set of activities into those that belong to the "Supplier" and those that are performed by BEP. Lanes are sub-partitions of pools, such as "BEP Receiving Function(s)".

Artifacts

Artifacts provide additional information about processes. Some artifacts are specifically defined in BPMN, but modelers may also add artifacts as required, as long as the depiction of an artifact does not conflict with another standard BPMN symbol. Standard artifacts include data objects, such as "Signed PO." Groups are another artifact which is represented by a box

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[2] It is possible to convert a file of invoices from a supplier's billing system into an "E-File" and send this to the IPP for posting as an invoice. This option was not, however, adopted by any supplier in the pilot.

[3] For those agencies with separate procurement and accounts payable systems, an optional IPP workflow module may be employed to route invoices to appropriate agency personnel for approval.

around a group of objects created for documentation or analysis. Figure 3 does not include an example of a group. An annotation, such as “Transmitted via FTP” is an artifact connected to diagram elements with an association that provides additional information.

IPP Represented in BPMNe

Following the BPMI philosophy governing allowable extensions, we built upon the BPMN standard. Our intent was to add sufficient richness to the notation so users can observe more easily *how* a shared process is affected by design elements. BPMNe (BPMN extended) is used to depict those additional physical implementation details that help explain why an interorganizational business process may be inefficient or ineffective. The general principle is that the extensions to BPMN can be removed, leaving a meaningful and valid BPMN diagram (in keeping with the BPMN goal of generating executable code). The extensions we added to BPMN include:

Participants and non-human actors

The participant symbol (see “Receiving personnel” in Figure 4) depicts *who* executes a business activity. Activity in a swim lane thus answers the *who* question, while the pool wherein the swim lane falls determines *where* activities are performed. Because all swim lanes are in pools, knowing *who* automatically answers the question *where*. Non-human participants, such as computer systems and servers, are not shown as actors – they are modeled as separate pools (see “IPP Server at Xign” in Figure 4), as dedicated swim lanes within a pool (see “BEPMIS/CAS” and “Enterprise adapter” in Figure 4), or as automated activities in a manual or combination lane (see below). (In some cases, participants and non-human actors can be adequately represented by the use of swim lanes and pools alone. In other cases, creating swim lanes and pools for each participant group and non-human actor could be unwieldy.)

Characterization of Activities

Process activities are categorized as Manual (M), Automated (A), or Human-computer interaction (I). Depending on a modeler’s needs, activities may be annotated to indicate how they are carried out. Where an activity is entirely manual, it is identified by appending an “M” to the activity description (see “Receive Paper PO (M)” in Figure 4) and by shading the symbol. Lanes that are entirely manual will have the column title shaded. Lanes with a combination of manual and automated activities will be so described in the lane title by suffix of M, A, I as appropriate (see “BEP receiving functions(s) – M, A, I” in Figure 4).

By convention, activities in a swim lane for a computer system or server are assumed to be automated. These tasks may be identified by appending an “A” to the activity description in the interest of clarity (see “Retrieve and display PO (A)” in Figure 4). Lanes that are entirely automated and symbols for automated processes will not be shaded. Human-computer interactions are identified by appending an “I” to the process description and include receiving computer output (see “Receive email from IPP (I)” in Figure 4), manually inputting data (see “Enter receipt data (I)” in Figure 4), or interceding in a computer operation, such as an operator starting a batch job. These activities are shown in

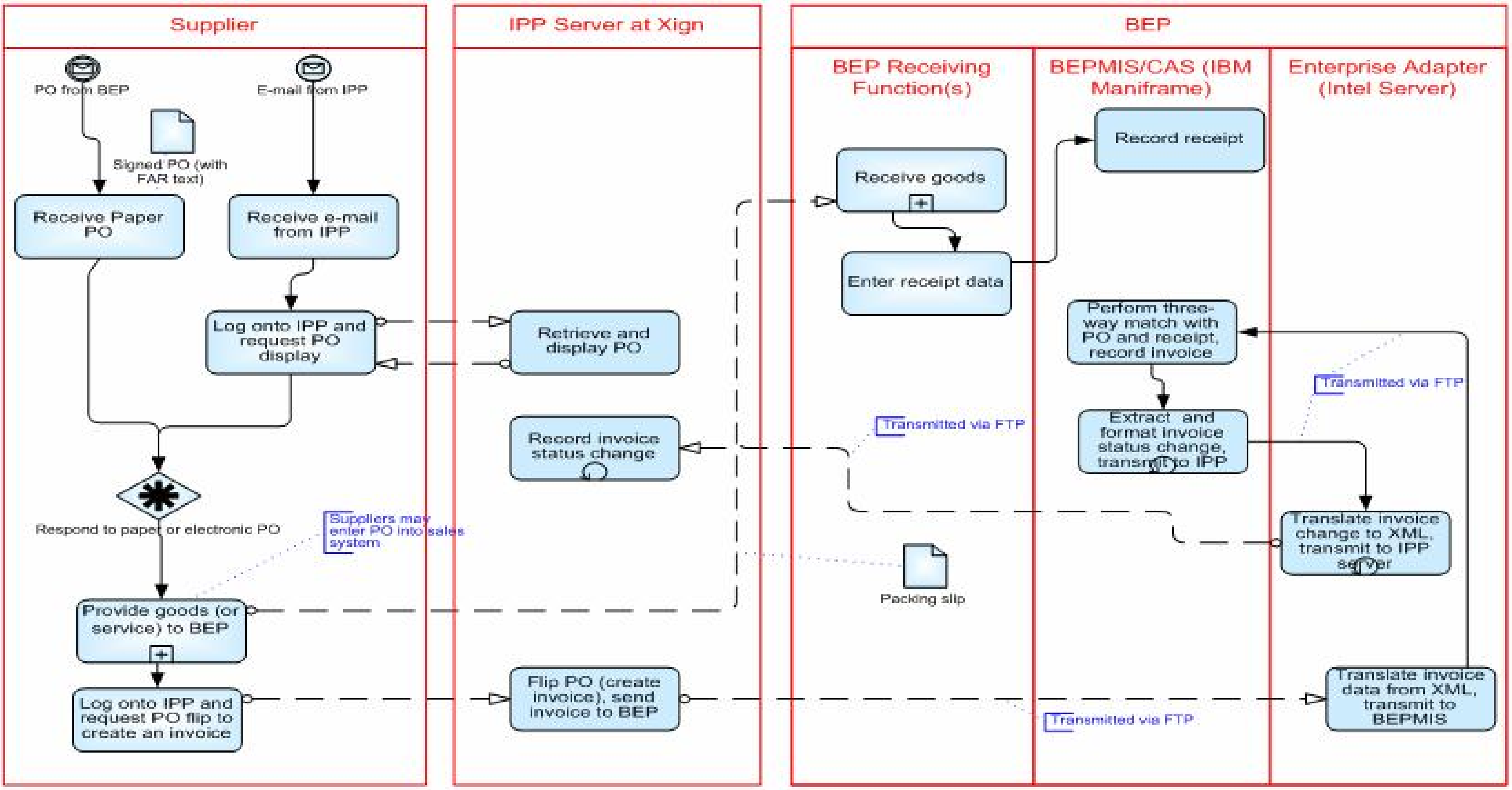

Figure 3. IPP invoice process, as implemented, depicted in BPMN business process representation.

a separate lane (see "BEP Receiving Function(s)" in Figure 4) or within a computer lane with an annotation. Activities in an organizational swim lane (e.g., "Purchasing department,") are assumed to be either manual or human-computer interactions; in other words, manual is the norm for human workflow systems. Activities with many sub-processes, some of which may be manual, automated, or human-computer interactions, will be annotated to indicate that possibility (see "Provide goods (or services) to BEP (M, A, I)" in Figure 2). The use of M, A, and I makes it clear whether a task is fully manual, fully automated, or a human-computer interaction. Incremental improvement initiatives might investigate whether manual activities are a source of process bottlenecks.

Manual data flows

A modeler's needs may also dictate whether manual and automated data flows are annotated. A manual data flow, such as a paper purchase order, may be shown by appending an "M" to the message (see "Signed PO (M)" in Figure 4).

Data stores

The data object symbol in BPMN is not intended to represent collections of data such as a database. Therefore, the traditional flowcharting symbol for database is used generically to show computerized and manual data stores as opposed to individual data items such as a purchase order. Electronic data stores are annotated with an "A" for automated (see "IPP Appreciating database (A)" in Figure 4). Physical/paper data stores would be annotated by appending an "M" for manual to the data store name (e.g., "Back Orders (M)").

Input and Output

A modeler might find it helpful to show input via a keyboard and output via a screen, as in the case of reading e-mail from a screen and then keying an order based on the e-mail contents. This could be evident from the activity description and the annotated message flows (e.g., "Re-key e-mail order"). It also could be indicated by the presence of a participant symbol. However, it might be useful to use traditional flowcharting symbols, such as "Manual input" and "Display". See Figure 4 for examples such as "PO display" and "Key receipt data."

Flow of material goods

The physical flow of goods can be shown as a message that has a goods symbol attached. The goods symbol message should be separate from a message, such as "Packing Slip (M)" so that goods flows can be removed from the BPMN diagram without loss of meaning. See, for example, "Goods" in Figure 4.

What BPMNe Reveals about IPP

Comparison of Figures 3 and 4 reveals that BPMNe has a richer representation of physical implementation details, including the *who*, *where*, *what*, *when* and *how* of the process. Although not obvious from a single diagram, process evolution can be reflected by a series of diagrams depicting the state of the IOS over time. And, the use of pools and swim lanes to represent each participant in an IOS gives a wide-angle view of the span of the interorganizational coordination effort.

Figure 4 depicts *who* performs each activity, *where*, and the physical movement of goods or information (*what*). For example, "Receiving personnel" key enter receipt data. BPMNe also depicts *how* each activity is performed. For example "Extract invoice status change data (A)" is automatic and requires no human intervention while "flipping" (converting) the PO into an invoice requires a human-computer interaction (see "Log onto IPP and request flip PO to invoice (I)" in Figure 4). This flip is performed once the goods or services have been provided. We should note that this human intervention would not have been needed had the suppliers opted to extract and send an electronic file of invoices to the IPP server. Even though the suppliers chose not to use the "E-File" interface, some of them rated the manual "PO flip" feature negatively at the end of the pilot. This is a good example of an implementation gap, because the E-file interface was clearly part of the planned (to-be) implementation, yet no users opted to use the e-File option when the system was put into use. The BPMNe notation "I" highlights this activity as a potential bottleneck, which indeed it is. In this case, the project team could have insisted on implementation of the E-File to increase vendor acceptance of the IPP.

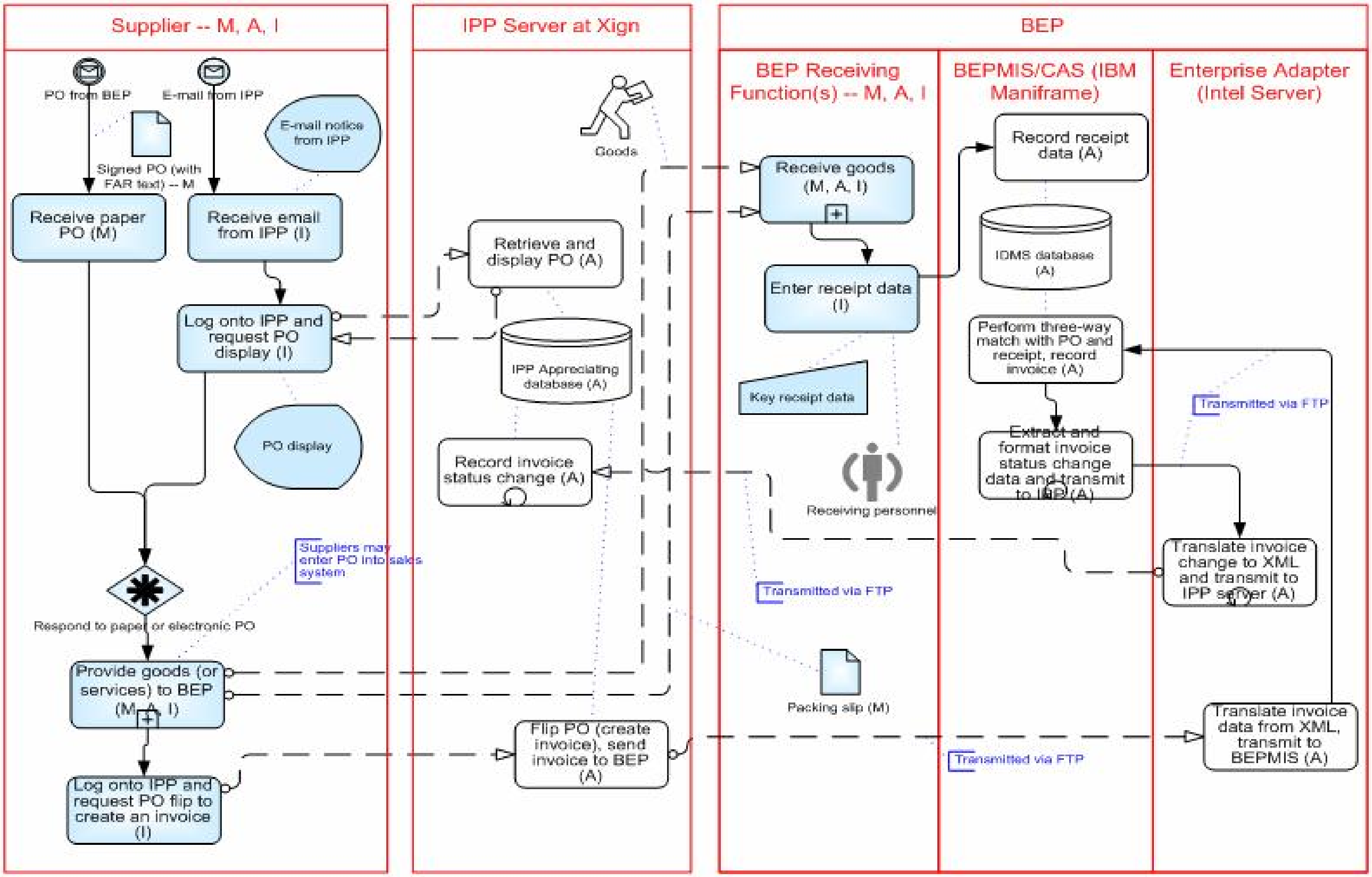

Figure 4. IPP invoice process, as implemented, depicted with BPMNe.

As shown in the left column of Figure 4, supplier personnel interface with two systems: e-mail (for notification of agency Pos) and IPP (to retrieve electronic Pos). Comparison of as-is and to-be (planned) diagrams would reveal that the mailed paper PO was added to the process after implementation of the IPP system. Our interviews explained that government contracting law required a PO to include often-lengthy attachments specifying contractual obligations and also required the entire document be signed. However, the electronic PO in the IPP pilot could not be digitally signed and could not accommodate large attachments. This is a second example of an implementation gap necessitated by real-world exigencies. The complex decision symbol labelled "Respond to paper or electronic PO" indicates that some suppliers waited for the signed paper PO, whereas others responded to the electronic PO. BPMNe also adds the data stores "IPP Appreciating database" and "IDMS database" to the IPP server and BEPMIS/CAS lanes. This highlights the duplication of data that exists in the IPP database and participant databases. Such duplication often occurs in hosted IOS, and it can be the source of limited adoption, errors in use, and so forth.

Our modeling approach adds value in several ways. The modeller can identify differences between planned (to-be) and actual (as-is) processes and reasons for less-than-expected implementation benefits. Examining extended physical as-is models can reveal process bottlenecks (e.g., by investigating M and I activities and those with the display symbol followed by keying activities.). Tinkering with physical implementation details can lead to process improvements without the need for a full-scale process reengineering exercise. Furthermore, the approach can result in a more complete and accurate physical model that can serve as input to process redesign efforts.

CONCLUSION

As more companies engage in complex interorganizational relationships, they need assistance in understanding, managing and coordinating their interactions. Internal and external systems and business processes should be documented and analyzed so that organizations can best accommodate their partners and attain benefits from the IOS in which they participate. An IOS modeling tool is valuable for understanding and analyzing these interactions.

In this paper we presented an IOS modeling approach than can help modelers identify obstacles to process efficiency and effectiveness. Our approach helps depict the systems and processes of all participants in an IOS. The addition of physical detail help capture *how* a coordination process is or could be enacted—a powerful tool for diagnosing inefficiencies and evaluating design options. Thus, this paper answers Riggins and Mukhopadhyay's (1994) call for more comprehensive modeling of interorganizational processes and systems.

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