An Innovative Method for Business Process Modeling

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Abstract. As a core area in the IS research field, business process modeling has long attracted theoreticians of new concepts, designers of artifacts, and practitioners of modeling. Their diligent efforts have resulted in numerous methods (e.g., UML, EPC, Flowcharts) for process modeling. The existing methods have been challenged in certain aspects. First, they mainly represent a flowchart model capturing only the normal flow of activities ignoring the depth or nested structure of processes. Second, they are informal or semi-formal, not lending to model checking and formal analysis without further translations and mapping procedures. Also the existing methods are more about control-flow than interaction of human actors. In this paper we discuss an innovative method hoping it will address the existing challenges and gap the disconnections, or, at least, provide an improved tool for that purpose. The proposed method encompasses a set of graphical notations fit into the concept it is based upon.

1 Introduction

Study of Enterprises Information Systems (EIS) cannot be performed completely and adequately unless conducted in the organizational and social context, in which the envisioned EIS will have to operate and support business processes. An EIS is not machinery alone or a collection of IT components, but a complex socio-technical phenomenon, where processes and people are the other two main components. The business processes, that an EIS supports, are better understood through the study of the interactions (communication, coordination, negotiation and commitments) enacted in the users' behavior as they carry out the organization's mission. Thus, an accurate EIS design entails a significant deal of human communication and interaction study (Winograd 1997). For example, a customer interacts with an insurance company to request a new policy. The insurance company agent makes a commitment to the customer to process the request and presents the customer with a result. Once the result is presented, it may lead to further negotiations, decline or acceptance of the result by the customer. The acceptance of the result also implies some obligations on the customer, such as the policy premium payment. This is what most researchers refer to as the interaction-based business process modeling approach developed within the Language-Action Perspective community and having roots in the speech act theory. The interested reader is referred to the Communications of the ACM Special Issue "Two decades of the Language-Action Perspective" (Communications of the ACM, May 2006, Volume 49, Issue 5), where contributions of pioneering authors of the LAP community are published.

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The emergence of Business Process Modeling as a dominant component in the EIS context has been widely recognized. According to (Ould, 1995), the importance of process modeling denotes a requirement for a number of ISO 9000 quality programs. Business process modeling is the basis of process-centric IT systems implementations, e.g., Enterprise Resource Planning systems (Robinson & Dilts, 1999). The increasing interest in business process modeling as a tool for capturing requirements and graphically documenting the processes of an organization to be supported by the envisioned EIS is widely evident from the mainstream literature (Dietz 2006). However, this complex social phenomenon is more complicated than the scope and features of the conventional methods used for its study.

A business process is not merely a flow of successful events, but rather a complex combination of activities, exceptions, and alternatives evolving in a horizontal progression as well as in vertical development, i.e., having breadth and depth in a layered and nested structure.

Finally, it is a fact that over the past few decades, businesses were misguided by the belief that IT alone will solve all their corporate woes, and consequently businesses overemphasized the role of IT while underestimating the importance of a clear understanding and critical analysis of their business processes (Carr 2003). However, the tide has turned and the prevailing standpoint in recent publications suggests a much greater focus on process-centric and process-driven enterprises, rather than merely investing in complicated expensive EIS. Therefore, in the hope of a humble contribution to fill this gap, in this paper we discuss and introduce a business process method based on an innovative concept derived from the Language-Action Perspective and based on Petri net formalism.

2 Related Works

Application of Petri nets in organizational and business processes is not a new research direction. Due to its formal semantics and intuitive diagrammatic representation, Petri nets have long attracted researchers to use them in business process modeling and design. An earlier paper introducing Business Process Petri Net is (Moldt & Valk 1998). More examples of research in this area can be found in a collection of papers in (Aalst et al. 1998) or in a comprehensive report of research works at Eindhoven University, Netherlands, (Aalst & Hee 2002). Most of the Petri net models proposed are dominantly process or workflow oriented rather than business process in the sense of socially interacting and communicating actors. In the framework that we apply Petri net, it is implied that the underlying system is of a social nature, an organization where social actors make requests, commitments, negotiations, and bring about new results. Thus, in the proposed method, the emphasis is placed on the social characteristics of business process that better fits service oriented organizations. In this regard it would be beneficial to mention that there are numerous studies on the suitability of certain business process modeling methods for one or another purpose (or perspective), e.g., for the purpose of business process documentation, business process analysis and design, IS/IT Application design, and so forth. Each of the methods fits well for a certain purpose or from a certain perspective. Bider (2005) based on an extensive analysis of existing methods, states:

"There is no universal method of business process modeling suitable for all possible projects in this field". Analogously, we hope that our proposed method would serve as a complement to the variety of existing methods with its suitability for a certain perspective. In particular, the proposed method is well suited for service oriented business systems with intensive interactions among participating actors, an organization and customers, and across organizational processes.

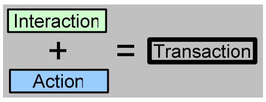
We believe that the proposed method along with its associated notations better contribute towards the requirements that a satisfactory method must meet in order to enhance communication of the user requirements to the system designers, and in order to adequately visualize the underlying conceptual notions. Some of the features that we hope this method excels in are: rich graphical representation and yet lending to formal analysis; modeling not only actions flow, but also actors' interaction; dealing with the deep (nested) structure of business process; embedded compact modeling. Since in the core of this method lies the business transaction concept, the main body of this paper is discussion of the business transaction concept.

3 Transaction: The Main Building Block

In the proposed method, the main concept and building block is called a *Transaction* (or business transaction) adapted from the DEMO methodology (Dietz 2003, 2006). According to the DEMO methodology, transaction has a generic pattern that consists of three phases, delivers a new result and is carried out by two actors in close collaboration. For example, applying for a new insurance policy is a transaction that involves two actor roles (a customer and the insurance company). The deliverable (result) of this transaction is a new policy. The *Transaction Concept* is based on the Language Action Perspective, one of the theories of Information Systems. Throughout this section, we will introduce different properties of a transaction along with the artifacts we have developed to diagrammatically represent the corresponding property that can be used for modeling business processes. The proposed artifacts are based on the Petri net formalism.

Transactions are patterns of interactions and actions, as illustrated in Figure 1a and distinguished by different colors. An *action* is the core of a business transaction and represents an activity that brings about a new result, changing the state of the world. An *interaction* is a communicative act involving two actors (actor roles) to coordinate or negotiate. Examples of an interaction could be "requesting a new insurance policy", "clicking an apply/submit button on an electronic form", "inserting bank card into an ATM to withdraw cash", or "pushing an elevator's summon button". Replying to the interacting actors and fulfilling their requests is an action, e.g., "issuing a new policy", "processing an e-form", "dispensing bills", and "moving an elevator to the corresponding floor".

Each business transaction is carried out in three distinct phases, the *Order phase*, the *Execution phase*, and the *Result phase*. These phases are abbreviated as O, E and R correspondingly (see Figure 1b), and constitute the OER paradigm (Dietz 2003, 2006). The figure illustrates a business transaction in detailed OER form and compact transaction form (T). Note that the order (O) and result (R) phases are interactions and the execution (E) phase is an action, therefore they are illustrated using different colors (the Execution phase is represented by a rectangle colored in blue, or gray in grayscale printout). These three phases are a distinct feature that entails the discussed method as a *business process* modeling technique versus just *process* modeling. The three phases not only allow for the boundary of an actor (or business unit) to be clearly defined, but also to depict interaction and action as a generic pattern involving (social) actors. Compared to UML, Flowchart, EPC and other conventional modeling methods, the transaction pattern clearly identifies the actors involved, as discussed below. In other words, in conventional methods, a transaction would be reduced to only one execution phase omitting information about the relevant actors and their role.

a) 

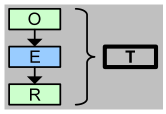
b) 

Fig. 1. a) The transaction concept, b) The OER diagram (detailed and compact notations).

In a structured language, a transaction is described according to Table 1, where a transaction is portrayed through the *activity pattern* it represents, its *initiator*, *executor*, and the *result* it delivers (or the new fact it creates). For illustration, policy issuance is described as a single transaction. Since real business processes are an arbitrary chain of transactions with the involvement of numerous actors, it is suggested to conveniently denote transactions by the letter "T" and accordingly number them (T1, T2, T#), and actors by the letter "A" and number them (A1, A2, A#).

Table. 1. Transaction description in a structured language.

Transaction:	**Issuing a new policy**
Initiator	Customer
Executor	Insurance company OR agent
Result	A new policy is issued

Now, we try to introduce the further notions of the transaction concept along with the Petri net notations we adapted. In general, Petri net structure consists of places (graphically illustrated by circles, representing the result of an activity or process), transitions (graphically illustrated by rectangles and representing an activity or process) and directed arcs (graphically illustrated by arrows and representing flow sequence). Figure 2a depicts a business transaction using the Petri net notations, where each of the three phases (OER) is represented as a transition (rectangle or box). In a compact notation, these three phases are compressed into a single transition, called Transaction (T). In the figure, the start and the end places are marked by different circles. These notations will show helpful when a complex process consisting of several sub-processes is modeled.

Another notion of the transaction concept is the role of actors involved in a transaction. Each business transaction is carried out by exactly two actors (or actor roles), see Figure 2a. The actor that initiates the transaction is called the *initiator* of the transaction, while the actor that executes the transaction is called the *executor* of the transaction. Since the Order (O) and Result (R) phases are interactions between the two actors, their corresponding transitions are positioned between the two actors. The Execution (E) phase is an activity solely carried out by the executor and, therefore, its corresponding transition is positioned within the confines (boundaries) of the executor.

From Information System perspective, a transaction diagram should also represent how the created result (data) is recorded. Since each transaction brings about a new result, the Result phase of a transaction is linked to an oval-shaped element representing the new result created (see Figure 2b). For simplicity sake, the depiction of the oval representing a transaction result may be omitted in the models studied later. If a business transaction is a simple one (not nesting further transactions), it is better to compress its three phases into a compact notation, see Figure 2c. In this case, the transaction is placed within the boundary of the executing actor, while the initiation and ending points are placed within the boundary of the initiating actor.

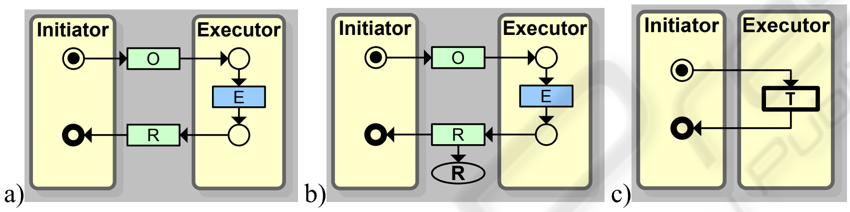


Fig. 2. A process diagram of transaction: a) detailed; b) with the result; c) compact.

Distinction is made between different types of transactions, simple (causal), composite, and optional transactions. Actors' interactions may be arbitrarily complex, nested, extensive and multilayered (hierarchical). A complex process typically consists of numerous transactions that are chained together and nested into each other. A *Simple* (causal) transaction does not involve (trigger or cause) other transactions during its execution (like in the above figure). It is carried out straightforwardly. In a *composite* transaction, on the other hand, one or more phases will trigger further, nested, transactions. For instance, think if actor A1 contacts actor A2 to reserve a hotel room (we denote this request as Transaction 1, or T1). Actor A2 receives the request and checks the room availability, but in order to fulfill the request, it has to request actor A1 for a payment guarantee (we denote this second request as Transaction 2, or T2). For actor A2 to complete the reservation transaction, first the payment transaction should be completed. This process is represented in Figure 3a in the form of a nested transaction. Notice that the Execution phase of T1 now has several sub-phases or interactions, where each of the sub-phases is distinguished with a letter of the alphabet attached to the transaction number (e.g., T1a/E denotes "first sub-phase of the Execution phase of Transaction T1"). The process illustrated in the figure starts with the receiving of a reservation request and checking the room availability, then it waits for the payment transaction to get completed, only then the Execution phase gets completed, let say, by conveying a confirmation number to the first actor. A close look at the reservation process reveals that in fact, the payment transaction, T2, is carried out between the hotel and a credit card company. Thus, the process rather involves three actors (actor roles): A1 (customer or guest), A2 (hotel receptionist) and A3 (credit card company). The interaction process between the three actors forms a nested transaction structure, which reveals the deep structure of business process usually ignored or omitted in conventional methods.

One of the limitations in many modeling techniques is coping with complex real-life systems. Usually models of real systems turn too large using diagrammatic representation. In dealing with this issue, we introduce the "composite" (or nesting) notation graphically represented as a multiple (layered) rectangle. For instance, the model illustrated can be reduced to one composite transaction as shown in Figure 3b. This can be applied to any part of a complex process for the sake of compactness or for spotlighting a specific part of the process while concealing the other parts. The notion of nesting structure is especially helpful in inter-organizational process modeling in which a whole process within an organization or business unit can be reduced to a single composite transaction, thus, keeping the model more manageable.

It should be noted that at any point (phase) an actor may quit the process or decline to proceed or a process is terminated due to internal or external circumstances.

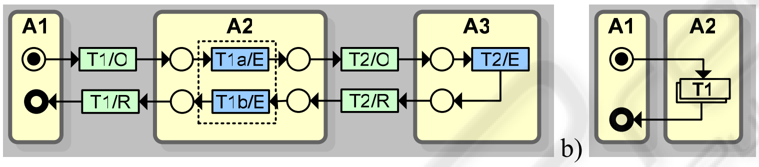
a)


Fig. 3. Nested transactions with three actors: a) detailed; b) compact.

In this manner, complex processes with any number of transactions, actors and outcomes can be modeled and illustrated. However, for more complex processes one needs to use often the compact notation of a transaction in order to keep the model better managed and controlled. The compact notation is useful for those transactions that are simple (not nesting further transactions). If a compact notation is used, by a convention, the whole transaction is positioned within the confines of the executing actor. Two instances of such a compact modeling are represented in Figure 4. In the first case, the nested transactions are initiated and executed in sequence, and in the second case, they are initiated and executed in parallel.

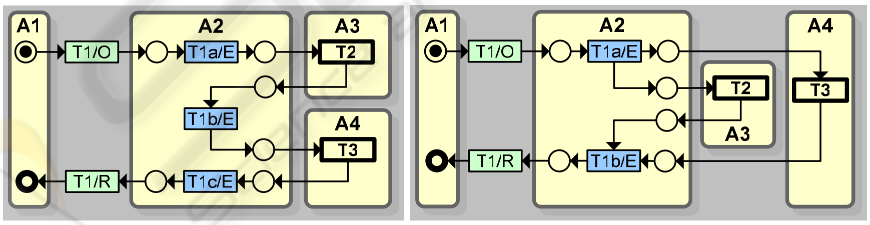


Fig. 4. A model with nested transactions: in sequence and in parallel.

Another notion, a typical phenomenon in process modeling, is of probability of some activities – optional transactions that may take place depending on some conditions. To indicate that a transaction is an optional one, a small decision symbol (diamond shape) is attached to its initiation (connection) point as illustrated in Figure 5a. In order to transform this optional transaction construct into standard Petri net semantics, a traditional XOR-split that could be modeled by one place leading to two transitions is used. It requires the addition of a skip (or dummy) transition as demonstrated in the figure (notice the tiny rectangle with no labels). A dummy transition means that it has zero duration and utilizes no resources.

Finally, there are situations that a process may halt and result in a termination. For example, if there is no room available, then the payment transaction is not initiated at all. This situation is modeled through a place identified as “decision state” graphically represented via a circle with the decision symbol (diamond shape) within it, see Figure 5b. As it is seen, for the transformation of a decision state into standard Petri net semantics, a traditional XOR-split that could be modeled by one place leading to *proceed* or *stop* is used. Depending on the value of the state, the process either proceeds or terminates as indicated by a place filled with a cross.

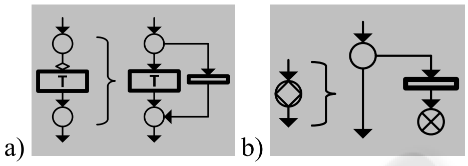


Fig. 5. Standard Petri net representation of: a) an optional transaction; b) a decision state.

Through these few simplified constructs and mini-models, we aimed to introduce how the proposed method can capture typical situations in a business process, provide sound concept based on communication, and ultimately contribute towards more accurate Business Process Modeling and consequently more adequate EIS Design. Now that the basic ideas and constructs of the proposed method are introduced, in the following section we illustrate how this method can be applied to a simple real world business system.

4 Case Study

What follows is a partial version of a case study demonstrating the proposed method’s capability of capturing the system interaction with external and internal entities (actors). This study was conducted when a large regional Pharmacy was planning to acquire and implement a new system and extend its business with e-commerce. This case study was conducted to help understand the Pharmacy’s operations and requirements for a new system.

A patient requests prescription refilling by submitting a prescription to the pharmacy technician (pharmacist). For new patient, the technician creates a profile in the pharmacy system’s QuickScrip database. After selecting a medicine, the system checks the current medicine for interactions with prescriptions the patient is already taking. The user is alerted if any interactions are found and the process stops. If there are no interactions, the user is asked by the software to transmit a claim to the patient’s insurance company, if one is provided. The computer generates a label and sends the information to the ‘robot’ for automatic filling. The medicine is dispensed into a pre-selected bottle and counted using a laser and gear system which places the medicine into the bottle. A conveyer belt sends the prescription out for a final check by a pharmacist. Once verified, the prescription is bagged and then sent out to the *cashier for pick-up by the patient. The entire process normally takes no more than 10-15 minutes. At the pick-up counter, the patient signs for their prescription and pays the cashier. Every time a new prescription is issued, the inventory is also updated. The inventory control sub-process entails a number of activities (transactions) that are out of the scope in this part.*

4.1 The Pharmacy Transactions

The process of "Prescription Filling" starts when a patient presents a prescription to be filled. Thus, the first transaction (T1) is "filling prescription". Actually, this is a super transaction that nests other transactions. This transaction is initiated by a "patient" and executed by the "technician". The result of this transaction is a filled prescription. In this manner we identify all other transactions (see Table 2):

Table. 2. Transactions of the pharmacy case.

T1:	**Filling prescription**
Initiator	patient
Executor	technician (pharmacy)
Result	A prescription is filled
T2:	**Creating profile**
Initiator	technician
Executor	patient
Result	A profile is created
T3:	**Checking medicine interaction**
Initiator	technician (software agent)
Executor	QuickScrip
Result	An interaction fact is established
T4:	**Processing claim**
Initiator	technician
Executor	insurance company
Result	A claim is processed
T5:	**Dispensing medicine**
Initiator	technician
Executor	robot
Result	medicine is dispensed
T6:	**Paying for the medicine**
Initiator	technician
Executor	patient
Result	medicine is paid

Now, based on the transactions identified, we build a detailed business process model of the pharmacy system as shown in Figure 6. The model is constructed in MS Visio using a customized stencil. By disclosing Transaction T1 (splitting its three phases), all other nested transactions are revealed. This figure shows that once medicine is issued (T1/R), the inventory control process is activated. As the inventory control process is out of the scope, which itself is a network of transactions, we just illustrate it as a composite transaction (T#). Within the scope of our model, only Transaction T1 is a composite transaction and, therefore, we decompose it. All other transactions (T2, T3, T4, T5 and T6) are simple transactions and, therefore, are represented in a compact form to keep the model condensed.

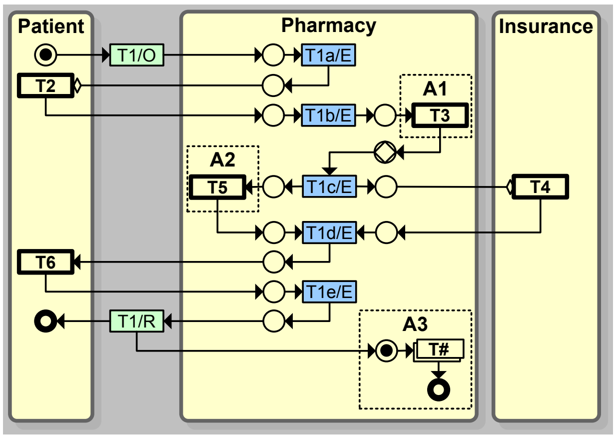


Fig. 6. The Pharmacy detailed model (constructed with MS Visio).

In the above figure, the Pharmacy is considered as a composite actor delegating the role of a few other actors such as “pharmacist”, “technician”, “robot” and “software agent” for checking medicine interactions. In order to better understand the above figure, it should be read from left to right and from the top down, just as the arrows indicate: The patient requests prescription filling (T1/O) and with this request the execution process starts (T1a/E). If it is a new patient, the technician asks them to fill in a form to create a new profile (T2). This is an optional transaction indicated with a small diamond-shape at the connection point. Then, within the pharmacy system (QuickScrip), a request is made to check the current medicine for any interaction (T3) (if an interaction is detected, the process terminates here, notice the output circle of T3 containing diamond shape). If the patient is covered by an insurance plan, through an online system, a claim is transmitted to the patient’s insurance company to define the price of the medicine (T4). Then the robot is instructed to fill in the prescription (T5). At this point the patient is requested to make their portion of the payment (T6), and only then the medicine is issued to the patient and the process is completed (T1/R). Notice, the completion of this process triggers a transaction in the inventory control process (T#) making sure the issued medicine is subtracted from the inventory and checks if this medicine should be ordered for restocking.

5 Evaluation

Hevner et al. (2004) suggest that methods deploying artifacts should be evaluated using *observational* (e.g., case study) and *experimental* (e.g., simulation) methods. Observational (case study) approach reveals the applicability potential of a method and its artifacts in a given environment and category that are targeted by the method. For example, case studies on different size organizations, different levels of complexity, different levels of abstraction, but all within the same category, e.g., service oriented organizations (insurance companies, healthcare/hospitals, hotels).

Experimental (simulation) approach reveals if models can be checked, analyzed and verified. This not only allows models to be checked for consistency, but also eliminates syntactic errors, illustrates dynamic behavior of models, and lends to formal analysis.

In light of these recommendations, the proposed method has been tested on both observational and experimental bases. A dozen case studies have been conducted using the proposed method and discussed among peer experts in peer-refereed publications. Some of them purposefully were conducted with the involvement of non-experts to not only evaluate the method, but also its complexity and mastering by only lightly trained analysts and system designers. Since the resulting models are based on formal semantics of Petri net, each of the models has been straightforwardly simulated, using Petri net tools, to check the models accuracy. All the models were communicated to and discussed with the users and researchers, including within the MSVVEIS and ICEIS community. Actually, an earlier version of this paper is published by both ICEIS and ECIS. The feedback obtained from modelers, designers, users, and researchers greatly helped to polish and improve the method and eliminate flawed constructs. Although, it is not claimed that this method is now the best, and therefore we urge researchers to use and analyze it. The feedback received, however, confirms that this method has a promising potential within the community. We would appreciate to see more researchers use the method and give it a critical analysis.

6 Comparison

There are a plethora of methods developed or adapted for business process modeling that one could discuss for comparison with our method, but neither the scope of this paper, nor the available space allows us to do so. Therefore, we confine our brief discussion to only a few widely used methods.

As for the comparison of the proposed method and its performance against widely accepted conventional methods such as UML, EPC and other Flowchart methods, the main distinction that should be made is the social emphasis of the proposed method, where involved actors and their interactions are captured as well as the actions they perform. It is a fully business process oriented modeling method incorporating the social character of systems. Furthermore, most of the conventional models are checked and analyzed via translation to other formal diagrams using mapping procedures. For instance, UML activity diagrams are often translated to Petri nets for checking (e.g., see Eichner et al. 2005; Eshuis 2006), and several tools are developed to translate UML diagrams to Petri net for further simulation (e.g., P-UMLaut tool converts UML 2 Activity and Sequence diagrams into high-level Petri nets for further simulation and 3-D animation). Another widely accepted method, investigated in (Dehnert & Aalst 2004), is Event-driven Process Chain (EPC). The authors propose a 5-step guideline to translate EPC models to Petri net models in order to investigate whether the process is correctly described in EPC. The analysis showed that ambiguities of EPC models will result in faulty Petri net executions. In this regard, the superior advantage of our method is its direct adaptation of Petri net formal semantics for the developed notations and constructs. Thus, analysts do not need further translations that could potentially compromise the accuracy and adequacy of modeling, or cause further sophistication through the development of mapping procedures.

As for the modeling notations that compete with Petri net, e.g. BPMN, EPCs, Role-Activity-Diagrams, IDEF, UML, RIVA etc., the reasons for adapting Petri net are its formal semantics, logics and formalism, and also its widespread use among researchers, practitioners and a variety of academic disciplines. In addition, Petri net is supported by a large number of tools for its analysis. Aalst (1996) identifies three main reasons why Petri net possesses advantageous features: formal semantics despite the comprehensive graphical representation; state-based representation instead of event-based; abundance of analysis techniques. Process modeling techniques ranging from informal techniques (e.g., dataflow diagrams) to formal ones (e.g., process algebra) are event-based, while Petri net approach allows state-based modeling. As mentioned, many of the models developed using conventional methods and techniques are eventually translated into Petri nets for model checking or validation and verification.

7 Conclusion

This paper presented an innovative method for business process modeling based on the concept of communication as a tool for elicitation and identification of action patterns.

The graphical language of Petri net makes it easier to communicate the models among analysts and users, while at the same time they are based on formal semantics. Thus, the models are fully graphical for illustration, and formal to enable complete analysis and powerful animation as well as simulation. In turn, it allows checking of models for correctness in describing business processes. However, in keeping models manageable and yet easily readable, one obvious trade-off takes place in the proposed method. This trade-off concerns the use of labels for the activities (e.g., T1, T2, T1/O, T1/E, for denoting transactions or transaction phases). Compared to typical flowchart models, where each rectangle contains a brief description of the underlying activity, our method may seem more technical and less readable. The flowchart models are easy to follow, but they are challenged when slightly complex processes are modeled, in which case the chart is broken in pieces. In this regard, though the proposed method seems more technical, it can construct fairly complex models on a single sheet of paper, especially with the deployment of compact and composite notations.

There are a few potential directions this method can open up for future research:

- First of all, keep using the method in more complex real life systems to explore turns and twists of business processes and examine the proposed method's capability;
- Develop modeling guidelines for practitioners to use the method in a systematic way;
- Conduct more in-depth critical comparative analysis of the proposed method and conventional methods such as UML (use case, activity diagram), EPC, RAD;

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