

# Business Process Modeling: A Survey

Gang HE<sup>1</sup>, Gang XUE<sup>1</sup>, Shaowen YAO<sup>1</sup>, Zhongwei WU<sup>2</sup>

<sup>1</sup>National Pilot School of Software

<sup>2</sup>School of Information Science and Engineering, Yunnan University, Kunming, China

Email: jfx2011@gmail.com, mess@ynu.edu.cn, yaosw@ynu.edu.cn, kaisen72@gmail.com

**Abstract:** Business process modeling is the foundation of business process management (BPM). Recently, there are a large number of business process modeling approaches in BPM domain. Still, there are many differences in specific applications, due to the diversity of characteristics of the process environment and the features of business process modeling approaches. In this paper, we attempt to find the advantages and disadvantages of current business process modeling approaches through the analysis of their main features and the comparative analysis, which are based on a series of important evaluation criteria. The purpose of such a survey is to provide theoretical foundation and feasible guidance for business process modeling in this domain.

**Keywords:** business process modeling; business process management; business processes modeling approaches; features; evaluation criteria; survey

## 1 Introduction

Business process management (BPM) treats processes as assets that directly contribute to enterprise performance by driving operational excellence and business agility. BPM helps companies preserve capital, identify threats, minimize risks, streamline processes [1]. Business process management is a management method focused on aligning all aspects of an organization with the wants and requirements of clients. It is a comprehensive management method that promotes business effectiveness and efficiency while striving for innovation, flexibility, and integration with technology. BPM attempts to improve processes continuously. However, business process modeling is the first and most important step in BPM lifecycle[2]. With the development of Service-Oriented Architecture and Business Process Management technology, business process modeling approaches serve as the foundational theory of service combination and business process technology. At present, there are a variety of business processes modeling approaches. Each has its own features and fits a certain environment.

In carrying out this survey and reporting on it, reference to some other prior work can be made. Certainly there have been numerous surveys. The study by J.Mendling, H.A.Reijers&W.M.P.van der Aalst (2009) have analyzed existing research on relationships between model structure on the one hand and error probability and understanding on the other hand. As a synthesis they propose a set of seven process modeling guidelines (7PMG). Each of these guidelines builds on strong empirical insights, yet they are formulated to be intuitive to practitioners. Furthermore, authors have analyzed how the guidelines are prioritized by industry experts. In this regard, the seven guidelines have the potential to serve as an important tool of knowledge transfer from academia

into modeling practice. A detailed introduction on the 7PMG can refer to this paper [3]. Another study by Ruopeng Lu, Shazia Sadiq (2007) presents a viewpoint: The origins of process modeling languages are quite diverse, although two dominant approaches can be observed; one based on graphical models, and the other based on rule specifications. The goal of such research is to address this question: there is no report in literature that specifically targets a comparative analysis of these two approaches, on aspects such as the relative areas of application, power of expression, and limitations [4]. Significant research effort is also being devoted to developing software to assist in the design phase of the process lifecycle phase(Marquardt&Nagl,2004;Nagl,Westfechtel,&Schneider,2003;Schneider&Marquardt,2002). A research in this paper [5] (K.Vergidis, C.J.Turner, A.Tiwari, 2007) contrasted and summarized the main findings of literature research and a targeted survey conducted within the service industry in order to investigate the current state of research and practice regarding key aspects of business processes. The survey involved the participation of 25 respondents working in service industry sectors such as finance, public sector and consultancy. The paper demonstrated that although theoretical developments are dealing with sophisticated issues around business processes, the service industry is reluctant to adopt a similar perspective and still uses simple and manual techniques in dealing with business processes. Our survey seeks not only to find the advantages and disadvantages of current business process modeling approaches, but also to provide theoretical foundation and feasible guidance for business process modeling.

The remainder of this paper is organized as follows. Section 2 discusses the basic concepts of business process modeling, as well as the motivation. Section 3 represent the main evaluation criteria of business process modeling approaches which validated by some experts in

related fields. Sections 4 briefly introduces business modeling approaches and makes analysis by a unified instance; Section 5 is an overall comparison of business process modeling approaches.

## 2 Business Process Modeling

A business process is a flow of activities creating value by transforming some inputs into more valuable outputs according to a certain business goal. BPM is the main research direction for process-aware system involving approaches, techniques, and supporting tools towards process design, execution, and monitoring [6]. And it is the step-by-step algorithm to achieve a business objective. A process can actually be executed by a process engine, provided its logic is defined precisely and unambiguously. When a process definition is input to an engine, the engine can run instances of the process. The steps of the process are called activities. Business process modeling is the study of the design and execution of processes [7]. According to previous studies, we can summarize the primary motivation of business process modeling into the following points: 1) Formalize existing process and spot needed improvements; 2) Facilitate automated, efficient process flow; 3) Increase productivity and decrease head count; 4) Allow people to solve the hard problems; 5) Simplify regulations and compliance issues [7].

Although, there are many types business modeling approaches and technology, business processes and process modeling approaches have their respective features and special requirements. In other words, each business process modeling approach is not a completely suitable for anywhere. Thus, appropriate process modeling method selected is especially important. In order to achieve this goal, the evaluation criteria of business process modeling approaches which reflect their features seem indispensable.

## 3 Evaluation Criteria of Business Process Modeling Approaches

The most evaluation criteria of business process modeling approaches have been summarized in this paper [4]. The most important criteria include the following aspects:

**Expressibility:** the expressive power of a process modeling language that is governed by its ability to express specific process requirements reflecting the purpose of process modeling and execution. A process model is required to be complete, which should contain structure, data, execution, temporal, and transactional information

of the business process [8,9].

**Flexibility:** flexibility can be seen as the ability to deal with both foreseen and unforeseen changes, by varying or adapting those parts of the business process that are affected by them, whilst retaining the essential format of those parts that are not impacted by the variations. Or, in other words, flexibility is as much about what should stay the same in a process as what should be allowed to change [10,11].

**Adaptability:** which is the ability of the workflow processes to react to exceptional circumstances, which may or may not be foreseen, and generally would affect one or a few process instances [12].

**Dynamism:** the ability of the workflow process to change when the business process evolves. This evolution may be slight as for process improvements or drastic as for process innovation or process reengineering [12].

**Complexity:** the measures of the difficulty to model, analyze, and deploy a process model [13], as well as the support for the dynamic and changing business process.

**Formalization:** process model require formal language to express [14].

## 4 Analysis of Business Process Modeling Approaches

There are many kinds of process modeling approaches and tools at present. According to Hommes' research, approximate 350 category process modeling approaches which support Business Process Re-engineering at the present time [15]. These process modeling approaches have a wide range, from the traditional static data modeling (eg, DFD.) to the dynamic behavior modeling (Eg, Role Activity Diagram, Petri Nets, etc). Here, we will analyze relatively mature modeling approaches at the present time, which support for business process management, such as Petri net, Pi-Calculus, IDEF, Event-driven Process chain, Data Flow Diagram, Role Activity Diagrams.

### 4.1 Petri Net

The Petri net, a notion devised in 1962 by the mathematician Carl Adam Petri, is a formal graphical and mathematical modeling tool, which can describe and study information processing systems that are characterized as being concurrent, asynchronous, distributed, parallel, nondeterministic, and stochastic. In Petri's original conception, the symbols are the following [7]:

**Place:** Drawn as a circle, a place is a stopping point in a process, representing (in many cases) the attainment of a milestone.

**Transition:** A transition is a rectangle that represents an event or action.

**Token:** A token is a black dot residing in a place. Collectively, the set of tokens represents the current state of

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the process. During the execution of the process, tokens move from place to place.

Arc: An arc is a link from a transition to a place or a place to a transition.

As shown in Figure 1, it use Petri net describes the warehouse process of a company.

The strength of Petri net is their support for analysis of many properties and problems associated with concurrent systems [16]. Petri Nets is a very general model. Finite State Machines, Process Networks and Dataflow Networks are all subclasses of Petri Nets. As a mathematical model, it is possible to set up state equations, algebraic equations and other models governing the behavior of the system. Due to its generality and permissiveness, the model can be applied to any area or system that can be described graphically. But the more general the model is, the more complex it is. A major weakness of Petri Nets is its complexity. The problem may become unsolvable even for modest sized system [17,18]. Because of the link between Place and Transition is fixed, it is good at expressing in fixed structure of coupled system, but it is difficult to express loose and dynamic coupled system.

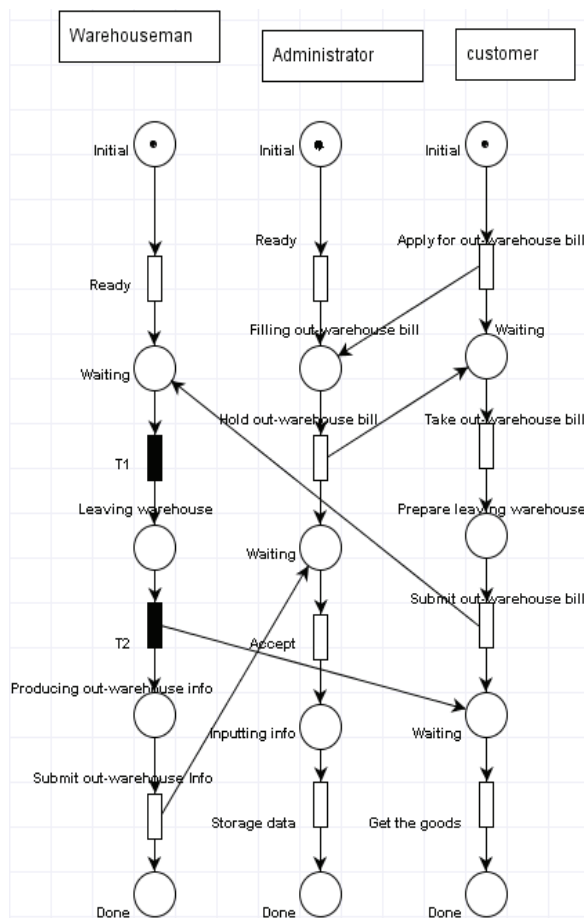


Figure 1. Petri net for out-warehouse of a company

## 4.2 Pi-Calculus

The pi-calculus [19,20], developed by Turing Award winner Robin Milner in the 1990s, is an algebraic system for building processes that communicate with each other on channels. Each process has a control flow that supports sequential, conditional, or concurrent control flow. Pi-calculus processes are written as sets of equations using a particular syntax. According to pi-calculus convention, when one process sends information to another, it includes the name of the channel to be used for the other process to respond. This name is variable; it can change in response to changing conditions. Channel change is referred to as mobility [7]. Thus, Pi-calculus expresses the loose and dynamic coupled systems very well, such as mobile communication systems, the Internet E-mail systems and service-oriented architecture, service combination, etc. As shown in the Figure 2, which indicates the relationship among three roles: A, B, C. A represent customer, B represents warehouseman, and C represents Administrator. This figure combine with expressions of Pi-calculus presents the communication among these roles of a company. As for more shortcomings of Pi calculus, you can refer to this page [21].

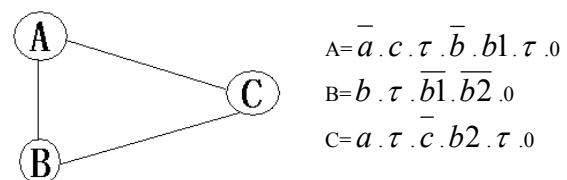


Figure 2. Relationship of three roles

## 4.3 IDEF Family

The IDEF family of languages is strongly linked to the Integrated Computer Aided Manufacturing (ICAM), which aimed to use the then emerging (1970's) computer technology in order to improve the manufacturing productive. There are numerous IDEF methods, but two of them serve as the basis for business process models: the IDEF0 method that focuses on activity modeling and the IDEF3 method that accomplishes process description and can be used to rapidly generate discrete-event simulation model specifications (Mayer *et al*, 1998).

### 4.3.1 IDEF0

IDEF0 adopts graphical symbols and natural language to describe and establish system function model on the basis of a top-down, hierarchical decomposition. Therefore, you can make an explicitly process modeling, it is easy to grasp and understand. IDEF0 is mainly used to establish

function model. Even more, it can define ‘what to do’ through process modeling, replying ‘why to do’ for enterprise. The basic elements of IDEF0 include four aspects: input, activity, output, mechanism and control; it also supports hierarchical decomposition of description. Figure 3 represents out-warehouse of a company.

### 4.3.2 IDEF3

IDEF3 describes processes as ordered sequences of events or activities. As such, IDEF3 is a scenario-driven process flow modeling technique, based on the direct capture of precedence and causality relations between situations and events. An IDEF3 model is a collection of one or more IDEF3 process schematics, which are built from UOB boxes, precedence links, and junctions in natural ways. The meaning of an IDEF3 model is best understood in terms of its possible activations, the possible real world situations that exhibit the structure specified in the model, for more detail about IDEF3 reference to this paper [22].

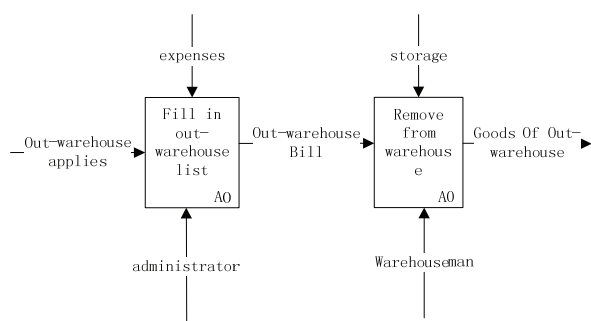


Figure 3. IDEF0 for out-warehouse of a company

Similar to IDEF0, the main strength of IDEF3 is the simplicity of its notation, which relies on only one basic construct, called the UOB (Unit of Behavior) [23]. As shown in Figure 4.

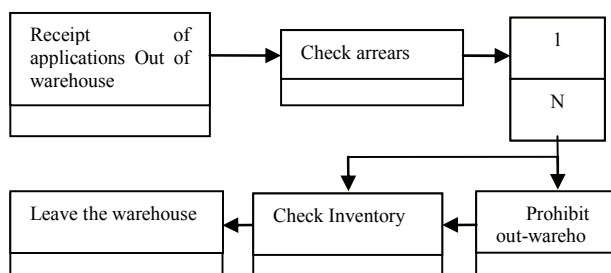


Figure 4. IDEF3 for out-warehouse of a company

IDEF family, especially IDEF0 and IDEF3 adopt

graphic symbols and natural language so that they are simple, accurate and easy to understand and master. Furthermore, they make use of hierarchical modeling approach, decompose the process of self-rule and have a clear description in relationship between process and procedure. However, IDEF family modeling approaches are basically static model and lack dynamism. Because of their mainly graphical expression, they have some weakness when express complex logic relationships.

### 4.4 Event-driven Process Chain

The EPC method was developed by Prof. Dr. August-Wilhelm Scheer at the Institute for Information Systems, University Saarland in the early 1990s within the framework of ARIS (Architecture of Integrated Information System). It is a business process modeling language representing temporal and logical dependencies between activities of a process [24]. And EPC is used by many companies for modeling, analyzing, and redesigning business processes. EPC diagrams are used to lay out business process work flows, originally in conjunction with SAP R/3 modeling, but now more widely. EPC diagrams use several symbols to show the control flow structure of a business process, including the following elements [25]:

#### 1) Functions

The basic building blocks are functions. A function corresponds to an activity (task, process step), which needs to be executed.

#### 2) Events

Events describe the situation before and/or after a function are executed. Functions are linked by events. An event may correspond to the post-condition of one function and act as a precondition of another function.

#### 3) Logical connectors

Connectors can be used to connect activities and events. This way the flow of control is specified. There are three types of connectors: ^ (and), XOR (exclusive or) and (or).



The main Symbols of EPC

We do not prepare to make excessive discussions over EPC, for more details about EPC, reference to [26,27]. Figure 5 is shown as out-warehouse process of a company with EPC.

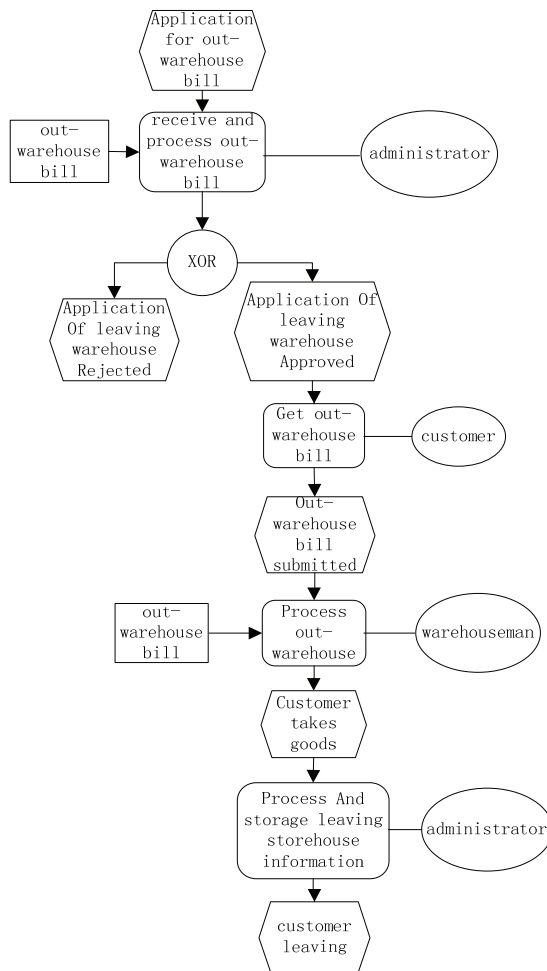


Figure 5. EPC for out-warehouse of a company

The strength of EPC lies on its easy-to-understand notation that is capable of portraying business information system, while at the same time incorporating other important features such as functions, data, organizational structure and information resources as already described before. This makes EPC as a widely acceptable standard to denote business processes [28]. However, neither the syntax nor the semantics of EPC are well defined. The semantics of a join connector of type is not clear and subject to multiple interpretations. As a result, an EPC may be ambiguous. Moreover, it is not possible to check the model for consistency and completeness. The absence of formal semantics also hinders the exchange of models between tools of different vendors and prevents the use of powerful analytical techniques [25].

#### 4.5 Data Flow Diagram

DFD is a graphical representation of logical systems that

can describe the system of logic models, and data stream flowing in the system and deal with the situation that data flow and process in the system. The main features of DFD: visual, simple and explicit. When it comes to conveying how information data flows through systems, data flow diagram (DFD) are the method of choice over technical descriptions for three principal reasons [29].

1) DFD is easier to understand by technical and no technical audiences;

2) DFD can provide a high level system overview, complete with boundaries and connections to other systems;

3) DFD can provide a detailed representation of system components.

Disadvantages: DFDs for large systems can become cumbersome, difficult to translate and read, and be time consuming in their construction. It is hard to support for Business process re-engineering; in the face of the resource conflicts, parallel processes, and representation of time and behavior state, DFD is very vague. In addition, it do not express the Dynamism of business process very well.

#### 4.6 Role Activity Diagram

Role Activity Diagrams (RADs) are a useful way of describing processes. They are valuable in documenting processes as they are now, and as they might be in the future. It is a visual notation for business process modeling. RAD is useful for modeling organized human behavior and interactions [30]. The elements of a RAD model are: roles-group together activities into units of responsibility; part refinements-describe parallel execution threads; case refinements-describe choices; activities-basic building blocks for describing work; interactions-activities requiring coordination with activities in other roles; external events-points at which state changes occurring in the environment influence on our process; states-useful to model point wise process goals; synchronization points-needed to synchronize threads originating from the same part refinement (reference to [31] for more details), as show in Figure 6.

RAD describes business process with the role, intention and rules, etc. The main feature that has a good description of the relationship between the activities, but RAD is just a static analysis of the relationship among the activities and less Dynamism.

### 5 Comparison of Business Process Modeling

In summary, we can see each modeling approach has its strength and weakness. In practice, we are unable to determine which method or technology is the best, when we actually carry out BPM, or Business Engineering

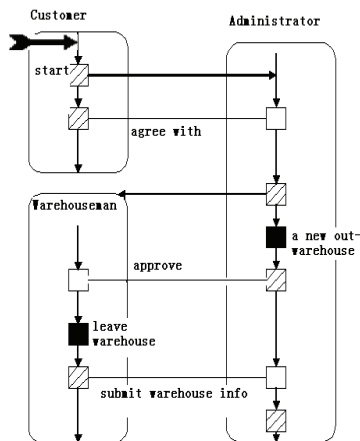


Figure 6. RAD for out-warehouse

(BE [32]). In fact, people are generally based on the actual goals and process's environment to choose more than one appropriate modeling approaches. So it is essential to summarize and compare features of these modeling approaches. First, in the form of a table shows a comparative framework, as shown in Table 1. On the one hand, these modeling approaches which based on some evaluation criteria of business process modeling in Section3; on the other hand, appending a number of modeling features such as modeling direction, the period of application and so on. Through the comparison of the table, we can find the features of business process modeling approaches clearly and discover the strength of various business modeling approaches. These can provide some reference for people in practice.

Table 1. A Survey of Comparative Business Process Modeling Approaches

|                          | Petri net     | Pi-Calculus       | IDEF0              | EPC                | DFD               | RAD           | IDEF3             |
|--------------------------|---------------|-------------------|--------------------|--------------------|-------------------|---------------|-------------------|
| Modeling direction       | Comprehensive | Process -Oriented | Function -oriented | Process -Oriented  | Process -Oriented | Role-Oriented | Process -Oriented |
| The Phase of application | Design Phase  | Analysis Phase    | Analysis Phase     | Analysing processe | Analysis Phase    | Comprehensive | Analysis Phase    |
| Expressibility           | good          | good              | Moderate           | Good               | good              | Moderate      | good              |
| Flexibility              | Weak          | Weak              | Weak               | Good               | moderate          | Weak          | Moderate          |
| Adaptability             | good          | moderate          | moderate           | moderate           | moderate          | moderate      | Moderate          |
| Dynamism                 | Very good     | Weak              | Weak               | Weaker             | Weak              | Weak          | good              |
| Complexity               | High          | High              | easy               | moderate           | easy              | moderate      | Moderate          |
| Formalization            | Very good     | Yes               | very small         | Yes                | Yes               | Yes           | very small        |

## 6 Conclusions

In this paper we have addressed some classical business process modeling approaches, including Petri net, Pi-Calculus, IDEF family, EPC, DFD, and Role Activity Diagram. This paper has presented a series of important evaluation criteria of business process modeling approaches, including expressibility, flexibility, adaptability, dynamism, complexity, formalization considerations. The analysis of these approaches reviews their strengths and weakness. Finally, we take this as the foundation, and carry on an overview comparison and evaluation to the business process modeling approaches.

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