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# A Comparison of Business Process Modeling Methods

Wei Wang, Hongwei Ding, Jin Dong, and Changrui Ren

**Abstract**—Business process modeling is the basis of business process management. The target of business process modeling is to get an abstract representation of the actual business processes. Although there are many business modeling methods, no well established modeling standard is available in this area. This paper reviews major business process modeling methods. Important aspects of these methods are discussed, including meta-model, graphical notation, serial representation, and tool support.

**Index Terms**—Business Process, Meta-model, Modeling, Analysis

## I. INTRODUCTION

ALL companies have business processes. Business process management becomes more and more important today. Maintained and optimized business processes will help companies achieve high efficiency in operations and be able to better compete in the market place.

Aalst [1] defined business process management as: *supporting business processes using methods, techniques, and software to design, enact, control, and analyze operational processes involving humans, organizations, applications, documents and other source of information.* Business process modeling is the basis of business process management. The target of business process modeling is to get an abstract representation of business processes. The representation could be graphical diagrams, and can also be exported to textual format. Many business process modeling methods have been proposed in the past. Many of them can cover the main requirements of business process modeling. But none of the proposals has been widely accepted and adopted as the standard in the area of business process management.

The rest of this paper is organized as follows. Major business process modeling methods are reviewed in Section II and III. Several aspects are compared, including meta-model, graphical notation, serial representation, and

tool support. A brief introduction of business process management lifecycle is presented in Section IV. Section V concludes the paper.

## II. MAJOR BUSINESS PROCESS MODELING METHODS

Major business process modeling methods are reviewed in the following. Some of them are originally designed for business process modeling. Some are general-purpose modeling methods, while support business process modeling. Some are designed for other purpose, but can be leveraged to be used in the area of business process modeling.

Most of the methods were proposed as standards for certain organizations. The corresponding organizations for these standards include OMG (Object Management Group), BPMI (Business Process Management Initiative), WfMC (Workflow Management Coalition), etc.

### A. BPEL4WS (Business Process Execution Language for Web Services)

BPEL4WS [2] is an industry standard created in a joint venture by BEA, IBM, Microsoft, and others. It's for the definition of business processes using web services. BPEL4WS supports the composition of complex processes by constructing and connection different activities to create a business process. BPEL4WS also provides a means of connecting web services and for specifying how collections of web services can be jointly used to provide more complex functionality in the form of a business process [3].

### B. BPMN (Business Process Modeling Notation)

BPMN [4] is the new standard for modeling business processes and web service processes developed by BPMI. BPMN defines a Business Process Diagram (BPD), which is based on a flowcharting technique tailored for creating graphical models of business process operations.

BPMN is expected to be accepted as the standard business process modeling notation. Many existing notations have been reviewed and leveraged during the development of BPMN.

### C. UML (Unified Modeling Language)

UML [5] is OMG's most referred specification for modeling. UML is widely adopted for the modeling of not only application structure, behavior, and architecture, but also business process and data structure.

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There are 13 diagrams in UML2, most of which are mainly for modeling object-oriented software. However, the activity diagram is exactly proper for business process modeling. Also there are corresponding elements in the superstructure and infrastructure of UML2 for business processes.

#### D. XPDL (XML Process Definition Language)

XPDL [6] is a process definition language proposed by WfMC (Workflow Management Coalition). It defines a common interchange format, which supports the transfer of process definition between different products. XPDL 2.0 is intended to be used as a file format for BPMN (Business Process Modeling Notation).

#### E. Petri Net

Petri net is a graphical and mathematical way for modeling. It consists of places, transitions, and arcs for connection. Petri net is very promising for describing and studying systems that are characterized as being concurrent, asynchronous distributed, parallel, nondeterministic, and/or stochastic. As a graphical tool, Petri nets can be used as a visual-communication aid, similar to flow charts, block diagrams, and networks. In addition, tokens are used in these nets to simulate the dynamic and concurrent activities of systems [7].

#### F. IDEF0 (Integration Definition Method) and IDEF3

IDEF0 [8] is designed for function modeling. It is a modeling technique based on combined graphics and text that are presented in an organized and systematic way to gain understanding, support analysis, provide logic for potential changes, specify requirements, or support systems level design and integration activities.

The IDEF3 [9] Process Description Capture Method provides a mechanism for collection and documenting processes. IDEF3 captures precedence and causality relations between situations and events in a form natural to domain experts by proving a structured method for expressing knowledge about how a system, process, or organization works.

### III. BUSINESS PROCESS METHODS REVIEW

In this section, principal building blocks of the business process modeling methods are reviewed and compared. A meta-model describes the components and rules when build a specific process model. Graphical notation is the graphical representation of a model and can make the model intuitive for understanding and communication. The results of modeling should be saved in certain format and interchanged between different tools. This relies on the serial representation. The modeling methods should also be supported by tools, so as to be used in practice.

These aspects are not isolated to each other. The graphical notation is tightly related to the meta-model, and the serial representation should be designed according to the meta-model.

#### A. Meta-model

A business process meta-model is a model that defines the language for expressing a business process model. Model elements are the components in the repository which can be used to build a model. Usually a business process model can be expressed as a directed graph, which consists of nodes and links.

Business processes can be described in two ways. Executable business processes model actual behavior of a participant in a business interaction. Business protocols, in contrast, use process descriptions that specify the mutually visible message exchange behavior. The process descriptions for business protocols are called abstract processes.

UML2 consists of two main parts: structure model and behavior model. The structure model can be treated as the basis of behavior model. There is a complex type hierarchy in behavior constructs of UML2. The main part can be illustrated below:

- Activity Node
  - Object Node
  - Control Node
    - Initial Node
    - Final Node
    - Decision Node
    - Fork Node
    - Merge Node
    - Join Node
- Activity Edge
  - Object Flow
  - Control Flow

The business process can be represented as a directed graph, which consists of nodes and edges. Some nodes denote executable action, or structured activity. Some are used to control the execution flow. In control nodes, initial node and final node are used to start and terminate a process respectively. Decision node and fork node represent a “one input, multi outputs” relationship. Fork node makes copies of the input, whereas the decision node does not. Merge node and join node represent a “multi inputs, one output” relationship. Join node is for synchronous combine of inputs, whereas merge node is for asynchronous combination. Object flow and control flow differs in the staff they carry.

In BPMN, there are four categories of elements, as listed below:

- Flow Objects
  - Event
  - Activity
  - Gateway
- Connecting Objects
  - Sequence Flow
  - Message Flow
  - Association
- Swimlanes
  - Pool

- Lane
- Artifacts
  - Data Object
  - Group
  - Annotation.

In BPMN, the concept of “sequence flow” is been emphasized. The term “control flow” is too ambiguous, and generally not used in BPMN. Association is used to associated data, text, and other artifacts with activities. It can also be used to show the inputs and outputs or activities. This makes the concepts clearer than ever. A gateway is used to control the divergence and convergence of sequence flow, just like traditional decision, merge, fork and join. Group and annotation are used for documentation of analysis purposes, and they do not affect the running of the process.

The XPDL and the BPMN specifications address the same modeling problem from different perspective. XPDL provides an XML file format that can be used to interchange process models between tools. BPMN provides a graphical notation to facilitate human communication between business users and technical users, of complex business processes [6].

The concept of a package is introduced in XPDL. An XPDL package corresponds to a BPMN Business Process Diagram, and consists of a set of process definitions.

Since XPDL is based on BPMN, its meta-model is close to BPMN’s meta-model. Some elements are added in XPDL to facility implementation.

- Process Definition
- Process Activity
- Transition Information
- Participant Declaration
- Application Declaration
- Relevant data field
- Data Type and Expressions
- System and Environment Data
- Resource Repository
- Vendor or User specific Extensions

A process definition consists of several activities. Activities are related to each other via transition information. Participant declaration provides the resources to perform activities. Application declaration describes the IT application invoked in the system. Relevant data field defines the data that is created and used within each process instance during process execution.

BPEL4WS is a notation for specifying business process behavior based on web services, and is layered on top of WSDL (Web Services Description Language) 1.1, XML Schema 1.0, and XPath 1.0 [2]. WSDL messages and XML Schema type definitions provide the data model used by BPEL4WS processes. XPath provides support for data manipulation. All external resources and partners are represented as WSDL services. The activities of BPEL4WS fall into two categories: basic activities and structured activities. Basic activities include:

- Invoke
- Receive
- Reply
- Assign
- Throw
- Wait
- Empty
- Terminate

Structured activities include:

- Sequence
- Switch
- While
- Pick
- Flow

The concepts are a bit different from neither UML2 Activity Diagram nor BPMN. In fact, some of the elements are related to web services, e.g. invoke is used to invoke web service operations, receive and reply are used to provide web services operations.

There are no corresponding elements for the activity edge of UML2 Activity Diagram, and connecting objects of BPMN. Instead, basic activities are contained in structured activities, which can be nested in other structured activities. In structured activities, pick and flow are a little special. Pick allows you to block and wait for a suitable message to arrive or for a time-out alarm to go off. Flow allows you to specify one or more activities to be performed concurrently.

BPEL4WS is designed to meet the needs in the environment of web services, whereas it is difficult to be used directly to model business processes. Actually BPMN can also be used for BPEL process modeling. An example is presented in the paper [10].

The meta-model of Petri net consists of a small set of modeling elements. There are only two kinds of nodes, and a single kind of link. Since Petri net is a state-based modeling methodology, it is quite different from the previous ones.

### *B. Graphical notation*

A consistent graphical notation is very important for communicating the models between different business analysts. Some common graphics tool, such as Microsoft VISIO, can be used to draw business process models. However the notation is not defined formally. Although most graphical notations obey some common rules, such as activities are rectangles and decisions are diamonds, a set of uniform notations is still needed.

BPMN and UML2 Activity Diagram are the most important notations. The author [11] has examined how 21 workflow patterns can be modeled with BPMN Business Process Diagram and UML2 Activity Diagram. Both are approved to be able to adequately model most of the patterns.

BPMN is likely to be a standard in this area. In BPMN, each modeling element has its well defined graphical representation. Figure 1 shows an example of business

process diagram.

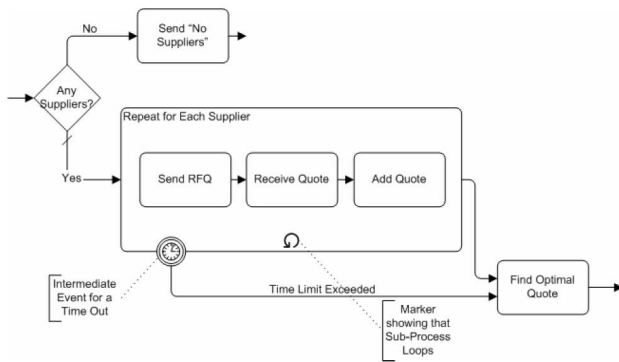


Figure 1. BPMN Business Process Diagram (BPD)

The notation for UML elements is optional, whereas recommended notations have been defined in official specification, and are adopted by most of tool vendors (Figure 2).

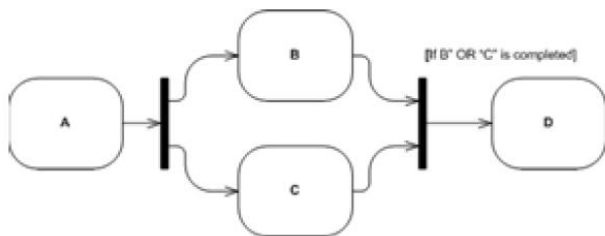


Figure 2. UML2 Activity Diagram

Petri net also has its fixed graphical notations. Places are represented as circles, and transitions are represented as double rectangles. IDEF0 and IDEF3 have explicitly defined graphical representations. Graphical information for XPDL and BPEL4WS is optional and tool dependent.

### C. Serial representation

The results of business process modeling should be saved in certain format, and interchanged between tools from different vendors. The file format, or serial representation of business process model plays the core role here. Most of the models adopt XML (Extensible Markup Language) as their serial representation, which is the standard of World Wide Web Consortium (W3C). XML is a simple, very flexible text format.

Mendling [12] presented a framework for comparing XML-based business process modeling specifications that builds on the superset of concepts extracted from the meta-models of 15 BPM specifications.

XMI (XML Metadata Interchange) is a model driven XML Integration framework for defining, interchanging, manipulation and integrating XML data and objects. XMI-based standards are in use for integrating tools, repositories, applications and data warehouses. XMI provides rules by which a schema can be generated for any

valid XMI-transmissible MOF-based meta-model. It also provides a mapping from MOF to XML [13].

BPML is another standard of BPML. It defines a formal model for expressing abstract and executable processes that address all aspects of enterprise business processes [14]. BPEL4WS is a XML based language, and BPEL4WS model is saved as XML files.

BPML and BPEL4WS are the two major standards in the area of business process modeling for web service. Mendling [15] compares BPML and BPEL4WS and makes conclusion that i) the two languages largely overlap, ii) none of both includes the other, and iii) from an academic point of view. It is necessary to develop a joint specification.

XPDL 2.0 [6] is intended to be used as a file format of BPMN. It is a direct competitor of BPML.

### D. Extensibility

Although all the methods above are designed to contain most of the constructs, which are likely to be required in business process modeling, there may be circumstances under which additional information. So the ability to extend or customize the model is fairly important.

UML2 has three extension mechanisms: stereotype, tagged value, and profile [16]. A stereotype defines how an existing metaclass (or stereotype) may be extended, and enables the use of platform or domain specific terminology or notation in addition to the ones used for the extended metaclass. Tagged value is the explicit definition of a property as a name-value pair. Certain tags are predefined. Users can define others. Constraint is a semantic condition or restriction, which can be described with Object Constraint Language (OCL).

XPDL supports vendor or user specific extensions. The XPDL elements can be extended by adding new child elements and new attributes.

BPEL4WS defines a set of extensions required in the definition of executable processes and business processes. The extensions are mandatory to be implemented for tool vendors.

### E. Tool support

If a method is not supported by any tool, it certainly has obstacles to be used in practice. All the models mentioned above have related tools. Some of the methods are strictly combined with specific tools, and some are supported by several different tools. Some tools are general-purpose, and can be used for several models, whereas some are special-purpose and can only be used for specified model.

IDS Scheer's ARIS and Proforma's ProVision are the two industry-lead general purpose modeling tools. ARIS (Architecture of Integrated Information System) platform is the product of IDS Scheer. ARIS provides four platforms: strategy platform, design platform, implementation platform, and controlling platform. These platforms cover all phases of a business process management lifecycle. ARIS is also the modeling tool used by SAP and by most SAP

developers. The product includes a number of features that support SAP modeling and development. It's the unique tool which is integrated with SAP NetWeaver. ARIS support model import and export in term BPEL. ARIS supports over 144 notations for modeling processes, data, systems, organizations, products, and services. Users can also create tailored notations and frameworks. BPMN and UML2 Activity Diagram are also supported in ARIS [17].

Proforma's ProVision, the ProVision modeling suite is an enterprise-wide visual modeling environment that enables organization to improve their performance and competitiveness. It provides modeling, analysis and simulation tools for all aspects of the enterprise, including strategy, processes, systems and technology. ProVision supports a range of pre-defined graphical notations, such as UML, and provides the ability to import custom graphic notations, and to create custom objects and properties. ProVision's workflow model currently supports BPMN at approximately the 85-90% level [17].

As one of the most popular modeling methods, UML is supported by lots of vendors. IBM Rational Software Architect (RSA) and Rational Software Modeler (RSM) are UML2 compliant tools. RSA unifies all aspects of software design and development into one powerful and easy to use tool. RSM is one part of RSA, and it is designed for UML modeling.

BPEL4WS is supported by IBM WebSphere Application Developer Integrated Edition (WSAD-IE) and IBM WebSphere Business Modeler (WBM). WSAD-IE is an Integrated Development Environment (IDE) for J2EE platform. A graphical BPEL4WS editor is embedded in it. WBM is a business process modeling tool that enables users to model, design, analyze and generate reports for your business processes, integrate your new and revised workflows, and define your organizations, resource, and business items. The meta-model used in WBM is generally based on UML2 (Unified Modeling Language, version 2.0), whereas it is designed for business processes modeling. The process models built in WBM can be exported to BPEL4WS for further IT-level development and deployment. WASD-IE and WBM are both tightly combined with IBM WebSphere Application Server (WAS), the industry leading application server. So the business process model can be implemented in an integrated environment.

#### IV. BUSINESS PROCESS MANAGEMENT LIFECYCLE

There are usually four phases in a business process management lifecycle, including design, configuration, enactment, and diagnosis (Figure 3). Business process model is the foundation in the management lifecycle and involved in all the four phases.

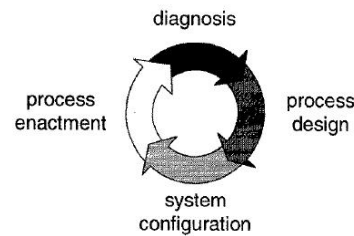


Figure 3. Business Process Management Lifecycle

Each of the four phases has its objective and features. In the design phase, business process model is captured from the existing physical processes. This model is usually called the As-Is process model.

In the configuration phase, business process model is adjusted to fit the actual environment of the operations.

In the enactment phase, the business processes are implemented in software systems and become executable in practical environment.

In the diagnosis phase, static and dynamic analysis methods are performed based on the business process model. The advantages and shortages of current business processes would be discovered for further improvement. Another round of process management cycle might be triggered.

#### V. CONCLUSIONS AND PERSPECTIVES

There is still no commonly accepted standard in the area of business process modeling. Major business process modeling methods have been reviewed in this paper, in terms of meta-model, graphical notation, serial representation, and tool support. These modeling methods have much common features and need to be consolidated.

More specifically, UML2 Activity Diagram and BPMN are good candidates for the meta-model and graphical notation. UML2 Activity Diagram is a mature industry model and is widely supported by tool vendors. But UML2 is a huge meta-model, and this makes its Activity Diagram a heavy-weight tool. It is then relatively hard to build the model. In contrast, BPMN is much concise. Since it is mainly for business process modeling, its structure is clearer, and easier to use. BPMN could be a high potential standard candidate for business process modeling.

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