IDEF Diagrams and Petri Nets for Business Process Modeling: Suitability, Efficacy, and Complementary Use

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Abstract

It is acknowledged that developing dynamic models of business processes prior to their change can contribute towards more successful Business Process Reengineering (BPR) projects. This paper investigates the suitability of IDEF diagrams (IDEF0 and IDEF3) and Petri Nets (DES-nets) for modeling business processes. After an introductory discussion of modeling issues and consequent requirements on modeling techniques, an example case of business process modeling using these modeling formalisms is presented. The suitability and effectiveness of the methods is discussed and a comparative evaluation of their features is provided. The results show that the methods can be employed in a complementary fashion as powerful tools to support a BPR project.

Keywords: Business Process Reengineering (BPR); business process modeling; simulation modeling, IDEF diagrams; Petri nets

1. Introduction

Organizational change efforts can be facilitated by various methods and tools for business process modeling, so that any changes to business processes can be tested on models prior to implementation (Curtis et al 1992). Some of the frequently mentioned problems related to organizational change include the inability to accurately predict the outcome of change proposals, difficulty in capturing existing processes in a structured way, shortage of creativity in process redesign, the level of costs incurred by implementing the new process, and so on (Paul et al, 1998).

To deal with some of the above problems, *business process modeling and analysis* is acknowledged as an important activity for Business Process Reengineering (Hammer and Champy 1993). Modeling typically involves acquiring business process descriptions and developing AS-IS models of the company's processes (i.e. models that depict the *current* way of doing things). Such models can provide BPR participants with the information needed to decide what to change, how to change it, and what the result of the change will be. The next phase is the development of TO-BE models that depict the *envisaged* process layout. These models can then be used to predict characteristics that can not be directly measured and to predict economic and performance data that otherwise would be expensive or impossible to acquire.

Growing interest amongst academic and industrial communities in organizational change and business process re-engineering has resulted in a multitude of approaches, methodologies, and techniques to support these design efforts (Wastell et al, 1994; Harrison and

Pratt, 1993). In this paper we will concentrate on two such techniques: *IDEF diagrams* and *Petri nets*. Both techniques will be described and compared according to their usage criteria and their basic elements. It will be shown that these two methods are complementary and can be combined and jointly used as a powerful tools to support a BPR project. The paper is structured as follows. Following an introductory discussion on the basic principles of IDEF diagrams and Petri nets, examples of business process models using IDEF diagrams and Petri nets are further provided. These methods are compared and their suitability for business process modeling is discussed. The concluding section outlines the main findings of our research.

2. Business Process Modeling Using IDEF Diagrams

IDEF (Integrated Definition) diagrams were introduced in 1981 as part of the Integrated Computer-Aided Manufacturing (ICAM) project. 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).

The IDEF0 method is designed to model the decisions, actions, and activities of an organization or other system and is targeted to communicating and analyzing the functional perspective of a system (Mayer et al 1998). Perhaps the main strength of IDEF0 is its simplicity, as it uses only one notational construct, called the ICOM (Input-Control-Output-Mechanism).

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 (Mayer et al 1998). The goal of an IDEF3 model is to provide a structured method for expressing the domain experts' knowledge about how a particular system or organization works (as opposed to IDEF0, which is mainly concerned with what activities the organization performs). 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).

3. Business Process Modeling Using Petri Nets

Petri nets are a method which enables graphical modeling of system behavior, while simultaneously enabling introduction of mathematical formal rules for system behavior definition (Törn, 1985; Yao, 1994; Oberweis and Sänger, 1992). Petri nets are one of the most widely used methods in modeling of parallel dynamic systems because of their characteristics: simplicity, representation power comprising concurrency, synchronization and resource sharing, strong ability of their mathematical analysis and application of software tools (Kamper, 1989; Thomas, 1993; David and Alla, 1994; Čerić, 1995). A whole variety of Petri nets extensions have been developed. Petri nets could be divided into three main classes: ordinary Petri nets, abbreviations and extensions (David and Alla, 1994).

The example of standardized Petri nets are *Discrete Event Simulation nets* or *DES-nets* (Čerić, 1995). DES-nets incorporate some simulation graphs extensions such as arcs with weight, timed transitions and inhibitor arcs. DES-nets incorporate also additional extensions, such as three types of *decision rules:* priority rules, probability rules and conditional rules. DES-nets use the following elements of colored Petri nets: token colors, token colors sets, place with inscription (colored place), arc with inscription (colored arc) and transition with a guard.

3. An Example Business Process Modeling Case

In order to demonstrate the suitability of IDEF diagrams (IDEF0 and IDEF3) and

Petri nets (DES-nets) for business process modeling, an example of process modeling using these methods is provided.

The IDEF0 diagram in Figure 1 shows a simple selling process model. The process is divided into three elementary basic activities: processing the order, dispatch of goods and invoicing. Order is the input data for the "processing order" activity. The sales department is involved in this activity and the control mechanism is used to compare the quantity of ordered goods with the quantity on stock. Output data is the order for dispatching goods. The order is at the same time input data for the "dispatch of goods" activity. The other basic activities are shown in the similar way.

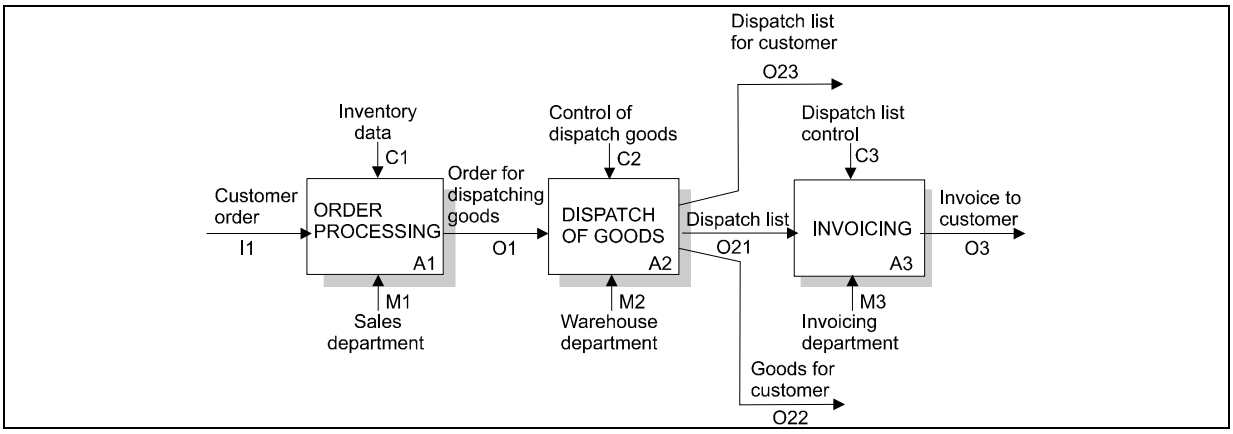

Figure 1: IDEF0 diagram of the simple selling process

The IDEF3 diagram shown in Figure 2 is used for detailed representation of the "order processing" activity. It represents the decomposition of A1 UOB (*Order Processing*).

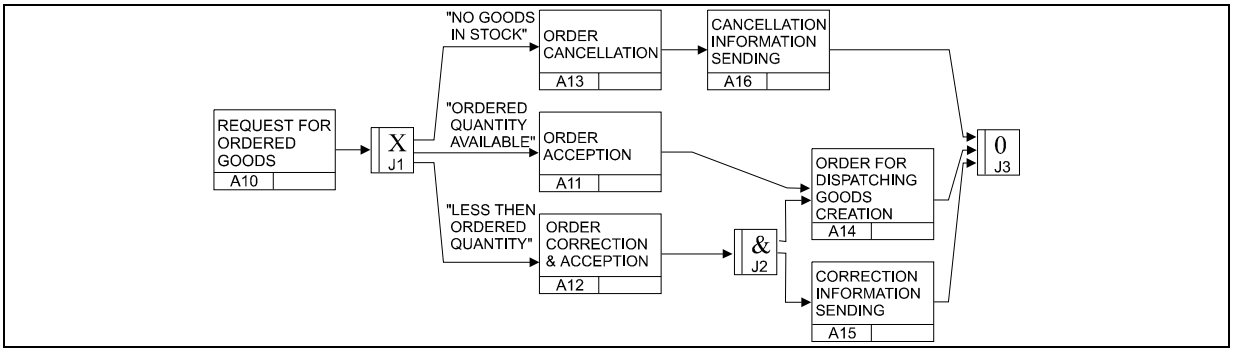

Figure 2: IDEF3 process flow diagram of the "order processing" activity

The "processing order" activity consists of several activities. The first one is the "request for ordered articles". It represents a comparison of the ordered quantities with the level of inventory that can result in three exclusive activities. These activities are connected with the preceding activity A10 by logic junction J1 (asynchronous, exclusive OR). This junction means that the preceding activity A10 must complete first, before exactly one of the following activities will start (these activities are shown in Figure 2 but are not discussed in detail). Figure 3 shows DES-nets developed for the previously defined scenario of the simple selling process. The arrival of orders is generated arrive every t_t minutes. There are two conditions which must be fulfilled to initiate the "order processing" transition: (a) at least one token in the "orders waiting" place and (b) at least one token in the "salesman ready" place (initially there are 5 salesmen). The "order processing"

transition fires and after t_o minutes one token of type (N,K) is deposited in the "ready to control" place. Depending on the probability rules and the capacity of the resources, further activities will be fired.

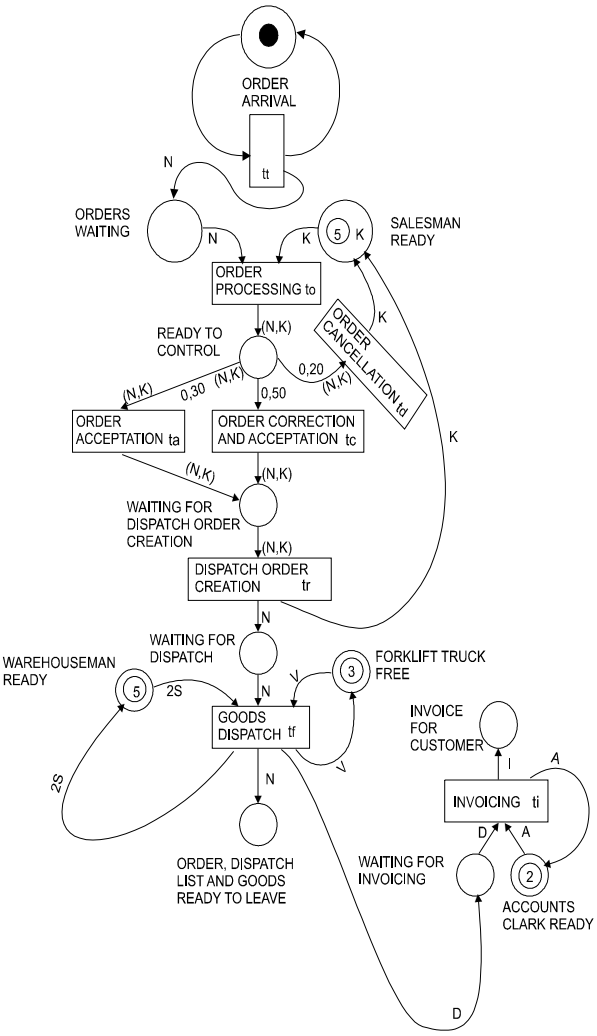

Figure3: DES-net of the simple selling process

5. Conclusions: A Comparison of IDEF Diagrams and Petri Nets

IDEF diagrams provide a mechanism for analyzing and documenting processes. They are designed to model decisions, actions and activities of an organization or a system. IDEF modeling is a very effective tool for communication between the analyst and the participants of the processes. IDEF diagrams show activities explicitly. Entities are shown with the data flow, whilst resources are presented implicitly, throughout the mechanisms. They can not represent all the elements important for simulation modeling, such as queues, random behavior and process dynamics, but could provide the basic elements for simulation model development. The example presented in Figure 3 shows that Petri nets are fairly straightforward since they use a limited number of symbols, but have large power of representation of system complexities. Petri nets are in particular well-suited for systems in which communication, synchronization and resource sharing are important since they have powerful abilities for representation of system dynamics: entity arrivals dynamics, availability of resources, interdependencies of resources, start and termination of activities, queuing time, number of entities in queue, conditions for events firing and other control mechanisms. These characteristics of Petri nets accomplish the typical goals of BPR. The presented modeling methods are compared in order to show their similarities and differences. IDEF diagrams and Petri nets are compared according to the criteria presented in Table1.

Usage criteria	IDEF diagrams	Petri nets
Simplicity	Very simple, but not available for very complex models	Fairly straightforward, even for complex models
Power of representation	Not very large	Very large
Hierarchical structure	Possible	Possible

Formalism	Not existing, or very small (elaboration)	Existing strong formalism
Standardization	Existing, very strong	Many versions, lack of standardization
Software	Numerous	Numerous

Table 1: A comparison of IDEF diagrams and Petri nets

IDEF diagrams and Petri nets can also be compared according to their basic elements, as shown in Table 2. We can conclude that IDEF3 diagrams are very powerful method with the basic elements for simulation modeling. IDEF0 diagrams show what happens in the model (activities, entities, resources and controls), but IDEF3 diagrams show how it happens (by junctions, precedence or temporal relation links, object states and state transition arcs in Object State Transition network). IDEF3 diagrams also capture detailed description and some elements of formalization in elaboration. Petri nets are more powerful methods for simulation modeling because they capture all the elements important for process dynamics and system behavior presentation. Graphical symbols of IDEF diagrams can be translated into appropriate symbols for Petri nets as it is shown in Table 3.

Elements	IDEF0 diagrams	IDEF3 diagrams	Petri nets
Process	Yes (connections of models in a network)	Yes (connections of models in a network)	Yes
Activity	Yes (box)	Yes (box)	Yes (transition)
Entity	Yes, implicitly (data flow through activity network)	Yes, implicitly (data flow and elaboration description)	Yes (tokens)
Resource	Yes (bottom arrow)	Yes (bottom arrow, elaboration)	Yes (tokens)
Queue	No	No	Yes (places)
Start/End	No	No	No special symbols
Event	No	Implicit (state transition arcs in OST network)	Yes (firing mechanism)
Control	Yes (top arrow)	Yes (top arrow and logic junction)	Yes (conditions, rules, arc guards, inscriptions)
Dynamics	No	Limited (temporal relation links and junctions)	Yes

Table 2: Comparison of IDEF0, IDEF3 and Petri nets elements

IDEF0 diagrams	IDEF3 diagrams	Petri nets
Action	Action	Transition
Link or arc	Link or arc	Arc
Text description of entities	Text description of entities, description in elaboration	Tokens
Resources	Resources	Tokens
Control mechanism	Control mechanism, logic junction, precedence links	Firing conditions, rules, arc inscriptions
-	Object states	Tokens in places
	State transitions arcs in OSTN diagram	Firing transitions rules
-	-	Queues

Table 3: Translation of IDEF diagrams symbols in Petri nets symbols

There are numerous software tools for both methods, but there is also a possibility of automatic translation of Petri nets into IDEF diagrams (Pinci and Shapiro, 1991; Shapiro, 1994). This possibility is widely used in business process modeling, especially in information system modeling (Pinci and Shapiro, 1991; Pinci and Shapiro, 1993).

This paper has demonstrated the usability of IDEF diagrams and Petri Nets for modeling business processes. A comparison of these methods was also provided. This comparison reveals that these two methods complement each other and that they can be used together for modeling business processes for better results. Due to their simplicity and

understandability, it seems appropriate to develop IDEF diagrams during the preliminary phases of business process modeling projects in order to develop "AS IS" models. In later phases, when "TO BE" models are developed, IDEF diagrams could be transformed into Petri nets which adds formal semantic to the models. Such an approach to developing models of business processes rather than changing real system directly can support BPR projects and increase the chance for their success.

References

1. Čerić, V., 1995., Petri Nets for Discrete Event Simulation. In: F.Breitenecker and I. Husinsky, ed. Eurosim 95, Simulation Congress Proceedings, Vienna: 1169-1174.
2. David, R. and Alla, H., 1994., Petri Nets for Modeling of Dynamic Systems - A Survey. Automatica 30, 175-202.
3. Hammer M. and Champy J., 1993., Reengineering the corporation. New York: Harper Collins Books.
4. Harrison B.D. and Pratt M.D., 1993., A methodology for reengineering businesses, Planning Review 21(2) 6-11.
5. Kamper, S., 1989., Object-Oriented Model Building with Petri Nets Using the Simulation Tool NET. Proceedings of the 3rd European Simulation Congress, Edinburgh: 142-147.
6. Mayer, R.J., Benjamin, P.C., Carawaz, B.E. and Painter, M.K., 1998., A Framework and a Suite of Methods for Business Process Reengineering. http://www.idef.com/articles/framework/
7. Oberwies, A. and Sänger, V., 1992., Evolutionary System Development: An Approach Based on Petri Net Simulation. In: J. Stephenson, ed. Proceedings of the European Simulation Multiconference - ESM'92, York: 172-176.
8. Paul R.J., Hlupic V. and Giaglis G., 1998., Simulation modeling of business processes. In: Avison D. and Edgar-Neville D., ed. Proceedings of the 3rd UK Academy of Information Systems Conference, June 1998. Lincoln: McGraw-Hill, 311-320.
9. Pinci, O. and Shapiro, R.M., 1991., An Integrated Software Development Methodology Based on Hierarchical Colored Petri Net. In: G. Rozenberg, ed. Advances in Petri Nets, 1991, Lecture Notes in Computer Science, Springer Verlag.
10. Pinci, O. and Shapiro, R.M., 1993., Work Flow Analysis. In: G.W. Evans, M. Mollaghasemi, EC. Russell and W.E. Biles, ed. Proceedings of the 1993 Winter Simulation Conference, Los Angeles: 1122-1130.
11. Shapiro, R.M., 1994., Integrating BPR with Image-Based Work-Flow. In: J.D. Tew, S. Manivannan, D.A. Sadowski and A.F. Seila, ed. Proceedings of the 1994 Winter Simulation Conference, Lake Buena Vista, Florida: 1221-1227.
12. Thomas, C., 1993., Hierarchical Object Nets - a Methodology for Graphical Modeling of Discrete Event Systems. In: G.W. Evans, M. Mollaghasemi, EC. Russell and W.E. Biles, ed. Proceedings of the 1993 Winter Simulation Conference, Los Angeles: 650-656.
13. Törn, A., 1985., Simulation nets, a simulation modeling and validation tool. Simulation, Vol. 45, No. 2, 71-75.
14. Wastell G.W., White P. and Kawalek P., 1994., A methodology for business redesign: experience and issues. Journal of Strategic Information Systems 3(1) 5-22.