Vlatka Hlupic
Brunel University, Department of Information Systems and Computing
Uxbridge, Middlesex UB8 3PH
United Kingdom

e-mail: Vlatka.Hlupic@brunel.ac.uk

and

Vesna Bosilj-Vuksic
University of Zagreb, Faculty of Economics, Department of Business Computing
Trg J.F.Kennedya 6, 10000 Zagreb
Croatia
e-mail: vbosilj@efzg.hr

Petri Nets and IDEF Diagrams: Applilcability and Efficacy for Business Process Modelling

Abstract:

It is apparent that developing dynamic models of business processes prior to their radical change could increase the success of BPR projects. This paper investigates a suitability of IDEF diagrams and Petri Nets for modelling business processes. Information modelling and simulation modelling are discussed from the business process re-engineering perspective. Examples of business process modelling using IDEF diagrams and Petri nets are presented. The suitability of these two graphical methods for business process modelling is discussed, and a comparison of usage of these two methods for BPR is provided.

Keywords: Business Process Reengineering (BPR), business process modelling, simulation modelling, IDEF0 diagrams, IDEF3 diagrams, Petri nets, DES-nets

Biography

Vesna Bosilj Vuksic received a Dipl.Econ. , M.Sc and Ph.D. in Information Systems from the University of Zagreb. She is an assistant professor of Simulation Modelling and Business Computing at the Faculty of Economics, University of Zagreb, at the Department of Information Sciences. Her current research interests are in graphical methods in simulation modelling, business process reengineering, information systems development and knowledge management. She is a president of the Croatian Society for Simulation Modelling (CROSSIM).

Vlatka Hlupic received a Dipl.Econ. and an M.Sc. in Information Systems from the University of Zagreb, and a Ph.D. in Information Systems at the London School of Economics, UK as well as a CEng from the UK Engineering Council. She is a senior lecturer at Brunel University, at the Department of Information Systems and Computing, and a director of the REBUS (REengineering BUSiness Processes) research centre. Dr. Hlupic has published over 80 papers in journals and conference proceedings, mainly in the area of simulation modelling and business process re-engineering. She acts as a consultant for a variety of service and manufacturing companies, as well as having held a variety of lecturing posts in England and Croatia. Her current research interests are in simulation software evaluation, business process modelling and in simulation packages.

1. Introduction

In order to survive in a competitive economic environment, many organisations need to continuously improve their business processes. This can be facilitated by using various methods and tools for business process modelling, so that any changes to business processes can be tested on models. Business Process Re-engineering (BPR) has become one of the most popular topics in organisational management creating new ways of doing business (Tumay, 1995). This management concept relates to the radical redesign of business processes in order to achieve more efficient, higher quality and more competitive production (Hammer and Champy, 1993). It is also a method of improving the operation and therefore the outputs of organisations that means analysing and altering the business processes of the organisation as a whole (Kovacic and Vintar, 1998).

An important initial activity for BPR projects is to acquire descriptions of the concerned business systems and to develop "AS-IS" model of the company's processes. "AS-IS" model (model of current business processes) provide BPR participants with the information needed to decide what to change, how to change and what will be the result of the change. The next phase is the development of "TO-BE" models that represent both existing and alternative processes. It must be validated and tested before the implementation. It can be used to predict characteristics that can not be directly measured and to predict economic and performance date 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). Kettinger et al (1997) conducted an empirical review of existing methodologies, tools, and techniques for business process change and developed a reference framework to assist positioning of tools and techniques that help in re-engineering strategy, people, management, structure, and technology dimensions of business processes.

Different methods are used for analysis and/or modelling of business processes such as: IDEF diagrams, Activity Based Costing Method (ABC), Total Quality Management (TQM), benchmarking, simulation and Workflow analysis. Some of the frequently mentioned problems related to BPR include the inability to accurately predict the outcome of a radical change, 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, or inability to recognise the dynamic nature of the processes.

This paper investigates the suitability of IDEF diagrams and Petri nets for business process modelling. A discussion on business processes related issues and an overview of business process modelling methods are presented. IDEF diagrams and Petri nets are described and compared according to their usage criteria and their basic elements. An example of business process modelling using both methods is provided, and the suitability of this method for modelling business processes is investigated. It is shown that these two methods are complementary and can be combined and jointly used as a powerful tools to support the BPR project.

The paper is structured as follows. Following a discussion on information system and simulation modelling, the basic principles of IDEF diagrams and Petri nets are presented. Examples of business process modelling using IDEF diagrams and Petri nets are further provided. These methods were compared and their suitability for business process modelling is discussed. Conclusions outline the main findings of this research.

2. Information System Modelling and Simulation Modelling as a Support for BPR

Business processes can be defined as a series of logically connected activities that use the company's resources. Davenport and Short (1990) defined a process as "a structured, measured set of activities designed to produce a specified output for a particular customer or market. It implies a strong emphasis on how work is done within an organization. Some common elements can be identified in a majority of definitions. These elements relate to the process itself (usually described as transformation of input, work flow, or a set of activities), process input, and process output, usually related to creating value for a customer, or achieving a specific goal (Paul et al, 1998).

One of the important methods in the implementation of BPR is information system modelling. The other is simulation modelling that is process-oriented, and thus fits naturally with the BPR concept. These two methods are discussed in the subsequent sections.

2.1. Information System Modelling and BPR

Awareness of IT capabilities should influence the design of business processes. In addition to investing in information technology, a new type of information systems models should be designed. The structure of information system model could be divided into the static and the dynamic part. The static structure of the model consists of functions, human and other resources, while the dynamic part consists of data, processes and events. The dynamic structure of information systems demands the implementation of process-oriented methods and tools.

Process models are often developed by graphical software tools that show business processes, activities and participants with flow diagrams and process charts. A disadvantage of these tools is that they are unable to perform process analysis. Process modelling tools must be able to show interconnections between the processes and to conduct a decomposition of the processes. These tools must help users to conduct "what-if" analysis and to identify and map nonvalue steps, costs, and process performance (bottleneck analysis). They should be able to develop "AS-IS" and "TO-BE" models of business processes.

The ability to support these requirements makes IDEF methods and tools valuable in BPR. IDEF methods and tools use visual models that facilitate the quantitative analysis of proposed changes to processes to achieve the highest performance at the lowest costs (deWitee and Pourteau, 1997).

2.2. Simulation Modelling and BPR

Simulation has an important role in modelling and analyzing the activities in introducing BPR since it enables quantitative estimations on influence of the redesigned process on system performances (Bhaskar et al, 1994). Recent development in simulation software made simulation particularly suitable to use in BPR (Van Ackere, Larsen and Morecroft, 1993). A re-engineering business process involves changes in people, processes and technology over time. As these changes happen over time, simulation appears to be a suitable process modelling method. Simulation is often called a technique of last resort because it is used when the system to be modelled is too complex for analytical models (Oakshot, 1997). The interaction of people with processes and technology results in an infinite number of possible scenarios and outcomes that are not possible to predict and evaluate using widely popular static process modelling methods. Kettinger et al (1997) mentions simulation as one of the modelling methods in their survey on business process modelling methods.

Reasons for introducing simulation modelling into process modelling can be summarized as follows:

- simulation enables modelling of process dynamics,
- influence of random variables on process development can be investigated,
- anticipation of reengineering effects can be specified in a quantitative way,
- process visualization and animation are provided,
- communication between clients and analyst is facilitated by simulation models.

Modern simulation software tools are able to model dynamics of the processes and show it visually, which then can enhance generating the creative ideas on how to redesign the existing business processes. Modern simulation software includes graphic user interface (GUI) that enables process animation and graphical display of simulation results.

One of the methods that could be used for modelling business processes is Petri nets. This method, described in more detail in Section 4, can allow a graphical representation of the dynamics and structure of business processes.

3. Business Process Modelling Using IDEF Diagrams

IDEF (Integrated Definition) diagrams, based on SADT (Structured Analysis and Design) diagrams, were introduced in 1981 as an integrated part of Integrated Computer-Aided Manufacturing (ICAM) project (Marca and Gowan, 1988). There are numerous IDEF methods, but two of them serve as the basis for simulation models: IDEF0 method that focuses on activities modelling and IDEF3 method that accomplishes process description and can be used to rapidly generate discrete-event simulation model specifications (Mayer et al, 1998).

3.1. IDEF0 diagrams

IDEF0 is a modelling technique used frequently in Computer Integrated Manufacturing systems analysis to get a good understanding of the system before BPR begins (Withers, Pritsker and Withers, 1993). IDEF0 model in the rectangle represents the activity (Figure 1). The left arrows in the rectangle display inputs, whilst the right arrows display outputs. The top arrows show constrains (controls) that start or stop all activities, and the bottom arrows display the resources (mechanisms) that participate in converting inputs into outputs.

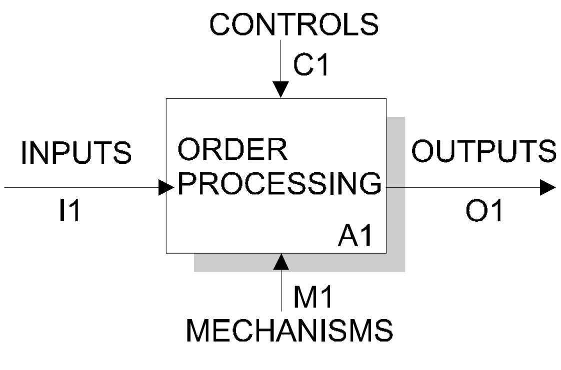

Figure 1: IDEF0 diagram

3.2. IDEF3 diagrams

IDEF3 diagram is a process-flow modelling method describing how activities work together to form a process (deWitte and Pourteau, 1997; Mayer et al, 1998). IDEF3 diagram identifies the behavior of the system. It builds structured descriptions about "what" a system actually does and "how" activities work together to form a process. There are two description modes: *Process Flow Diagram* and *Object State Transition Network*.

An IDEF3 process flow describes a process and the relations that exist between processes. The activities of the process appear as labeled boxes. The term for elements represented by boxes (activities, processes, events, operations, procedure) is a Unit Of Behavior (UOB). The boxes are connected by arrows that define the logical flows. The arrows are the same as in IDEF0 diagrams, but there are no bottom arrows (mechanisms). There are also the smaller boxes that define logic junctions: AND (&), OR (O), and exclusive OR (X). Logic junctions could present asynchronous or synchronous behavior among UOBs (they present inputs that proceed and outputs that follow the UOB). Each UOB can be decomposed and can be associated with a description of the objects and their relations, called elaboration.

The Object State Transition Network summarizes all the transitions an object may undergo throughout a particular process that is very useful for simulation modelling.

4. Simulation Modelling and Petri Nets

Petri nets are a method which enables graphical modelling of system behavior simultaneously enabling introduction of mathematical formal rules for system behavior definition (Törn, 1985; Yao, 1994; Oberweis and Sänger, 1992). This method can be used for modelling of any system where the regulation of object and data flow is important. Petri nets are one of the most used methods in modelling 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; Ceric, 1995; Dietz and Barjis, 2000).

4.1. Introduction to Petri Nets

A whole variety of Petri nets extensions were developed, each being specific, having certain extensions. Petri nets could be divided into three main classes: ordinary Petri nets, abbreviations and extensions (David and Alla, 1994).

Petri nets model events or activities (using transitions, depicted by bars) and conditions (using places, depicted by circles). Events (transitions) are connected by direct arcs with input conditions (places) which must contain at least one token so that the event can occur, and with the output conditions (places) that will be fulfilled after the accomplishment (firing) of the event. The system dynamics are depicted by tokens, which enter the places and leave them again after the event is completed. Each transition execution causes new state and new marking of network (Figure 2).

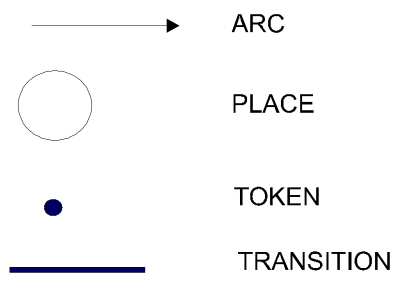

Figure 2: Basic elements of Petri Nets

In the *ordinary Petri nets* all the arcs have the same weight which is 1, there is only one kind of token, the number of tokens is not limited by place capacities and no time is involved.

The *abbreviations* enable simplified representations. The abbreviations are generalized Petri nets, finite capacity Petri nets and coloured Petri nets. Coloured Petri nets permit representation of token individuality by modelling of token type (e.g., doctors) and token classes of the same token type (e.g. physicians, surgeons). This colored Petri net approach is normally requested for discrete event simulation modelling (Jensen, 1992 & 1998).

There is a large and growing number of different Petri net *extensions* for discrete event simulation (Reisig, 1991; David and Alla, 1994; Heuser and Richter, 1992; Pinci and Shapiro, 1991; Törn, 1981). *Simulation graphs* incorporate very important extensions made for a simulation purpose (Törn, 1985). Most significant extensions are weighted arcs, inhibitor arcs, test arcs, terminate arcs, transition and places attributes, queues and entities. It is outside the scope of this paper to describe these extensions in further detail, as the details are provided in above mentioned references.

These extensions were introduced in the ordinary Petri nets in order to increase their modelling power and enable modelling of complex systems. A large and growing number of Petri net extensions prove Petri nets' capability and flexibility. On the other hand, it could be useful to define a standardized Petri net extension for discrete event simulation. The potential benefits could be: easier understanding and acceptance for simulation professionals and the ability to integrate the best Petri net extensions.

4.2. DES-nets

The example of standardized Petri nets are *Discrete Event Simulation nets* or *DES-nets* (Ceric, 1995). DES-nets incorporate some simulation graphs extensions already mentioned 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 assign priorities to all output transitions (lower priority value means higher priority). Probability rules assign probabilities to all output transitions (the sum of probabilities is equal to 1). Conditional rules provide a condition to be evaluated at the moment of decision making.

DES-nets use the following elements of colored Petri nets: token colours, token colours sets, place with inscription (coloured place), arc with inscription (coloured arc) and transition with a guard. Token colour sets represent types of tokens. Token colors represent different classes of tokens from the same colour set. Tokens with different colours are shown separately in places that they occupy. Their current number is written in a small circle accompanied by the name of the colour. Each place can contain one token colour set or colour sets' combination that must be attached (inscribed) to it. Each transition can have a guard attached to it. Guard describes token colour values that can enable this transition. Token colour values are incorporated in variables. Arc inscriptions can be constants (defining the combination of token colours traveling through the arc) or variables that constrain token colour values that can enable a transition.

5. The Suitability of IDEF Diagrams and Petri Nets for Business Process Modelling

Although the objective of this paper is not to describe and compare in detail different information system modeling methods and simulation modeling methods, a brief overview of their characteristics is provided in order to point out the advantages of IDEF diagrams and Petri nets for business process modelling.

Most of today's approaches to business process modeling start from an activity-centered perspective. Activity models, such as state charts, flow charts or data flow diagrams are used to define the activities within business process and the relations between them. In this research IDEF diagrams were selected and proposed because:

- they are used widely, especially for business process analysis and modelling (Pinci and Shapiro, 1993),
- they represent the only standard modelling and analysis methods for enterprise engineering (deWitte and Pourteau, 1997, Tatsiopoulos et al, 1999),
- IDEF diagrams support particular reengineering activities such as simulation modelling and information system modelling (Gladwin and Tumay, 1994).

Two overviews of discrete event simulation diagrammatic methods have been made relatively recently by Pooley (1991) and Ceric and Paul (1992) describing a set of the most widely used methods. On the basis of these reviews, Table 1 shows the comparison of Activity cycle diagrams, Event Graphs, GPSS block diagrams and Petri nets. The methods are compared according to the following criteria (Ceric, 1999): simplicity, power of representation of system complexities, hierarchical structure, formalism and software:

Usage criteria	Activity cycle diagrams	Event Graphs	GPSS block diagrams	Petri nets
Simplicity	One of the simplest diagrammatic methods	Very complex, experience is needed	Many tools, experience is needed	Fairly simple, even for complex models
Power of representation of system complexities	Not very large	Very high	High	Very high
Hierarchical structure	Possible but rarely exploited	Limited	Possible in principle	Possible
Formalism	Not existing	Exists	GPSS semantics and syntax	Existing strong formalism
Software (visual interactive modelling tool)	HOCUS, VS7	SIGMA for Windows	Other tools for processing network graphical modelling (SLAM, ARENA)	Design/CPN, ALPHA/Sim

Table 1: A comparison of simulation methods according to their usage criteria

Activity cycle diagrams are one of the simplest methods and therefore are very suitable for the end-users' understanding and the communication during BPR project development. They also have some disadvantages, such as: very limited representation power rarely exploited hierarchical structure and lack of formalism. *Event graphs* are very powerful method, but very complex and complicated to use. *GPSS block diagrams* have high representation power but the modellers need to have long experience for modelling of complex systems. They are formalised in GPSS simulation language that is not visual interactive modelling tool (instead other processing network graphical modelling methods such as SLAMSYSTEM and ARENA should be used). *Petri nets* have the following advantages: simplicity (can be used intuitive, without the experience), very high power of representation of system complexities, strong formalism, hierarchical structure and graphical, visual and interactive software tools. Their simplicity and powerful ability to represent complexities are the key features in relation to their suitability for business process modelling.

6. An Example of Business Process Modeling Using IDEF Diagrams and Petri Nets

In order to demonstrate the suitability of IDEF diagrams (IDEF0 and IDEF3) and Petri nets (DES-nets) for business process modelling, an example of modelling selling processes using those methods is provided.

IDEF0 diagram in Figure 3 shows the highest hierarchical level of a simple selling process model. Selling 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. In the dispatch activity warehouse staff takes part in and the control of the dispatched goods takes place (comparison of ordered and actually dispatched goods). Output data are: the goods delivered to the customer, a copy of the accounts dispatch list which initiates the invoicing and a copy of dispatch list to the customer. In the "invoicing" activity participates the account clerk, who at the same time settles the dispatch list and makes the price calculation. Output data is the invoice to the customer.

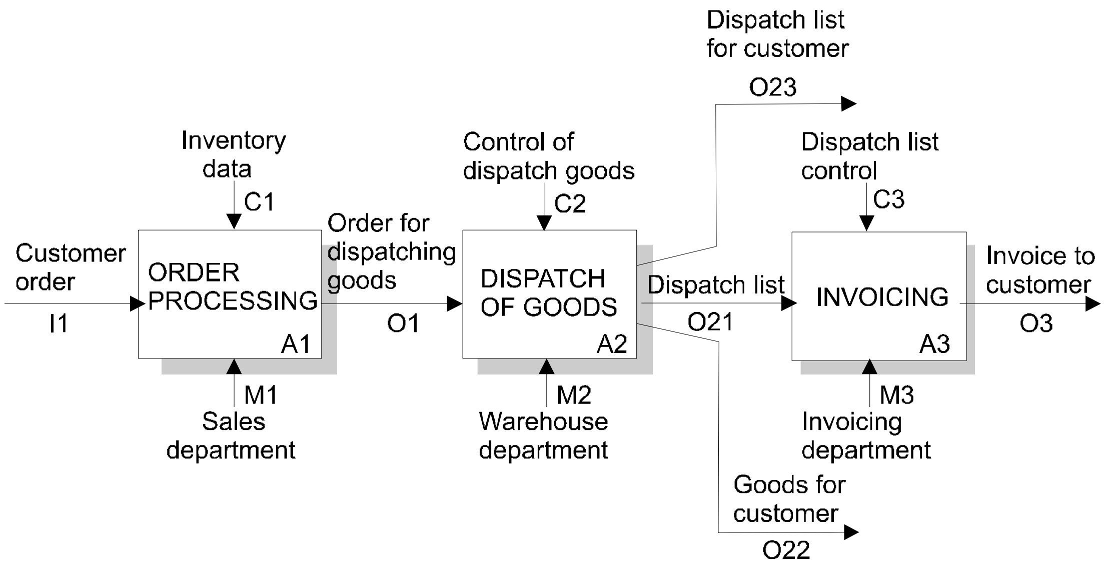

Figure 3: IDEF0 diagram of the simple selling process

IDEF3 diagram shown in Figure 4 is used for detailed representation of the "order processing" activity. It represents the decomposition of A1 UOB. 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 A1 by logic junction J1 (asynchronous, exclusive OR). This junction means that the preceding activity A1 must complete first, before exactly one of the following activities will start. If the ordered quantity is available, the order is confirmed (A11) and the order for dispatching goods is created (A14). If there is less than ordered quantity, the order will be corrected and accepted (A12) and then two activities will start simultaneously: A14 and A15 (the information about correction is sent to the customer). It is shown by the asynchronous AND junction (all preceding processes must complete and all following processes will start). If there are no goods in stock, the order is cancelled (A13) and the information about cancellation is send to the customer (A16).

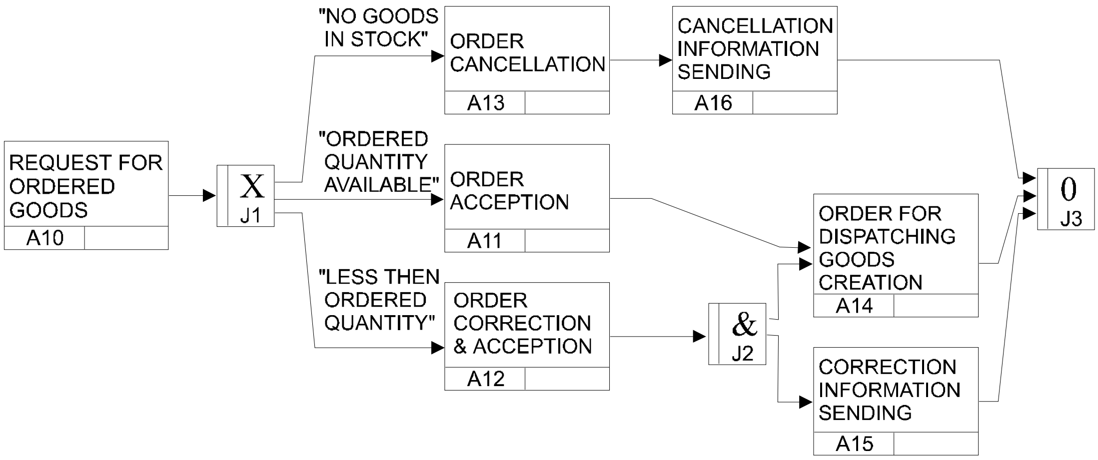

Figure 4: IDEF3 process flow diagram of the “order processing” activity

Entities (objects) and their states are explicitly shown by Object State Transition Network. Object states are represented by circles and object state transition arcs are represented by the lines connecting the objects. Figure 5 presents all the states of the "order" entity in the "order processing" activity. The order can be received, cancelled, accepted or accepted with the correction. Certain conditions must be fulfilled, or certain events must happen before the object state is changed. Between the "received order" state and the "accepted order" state the "request for ordered goods" must be finished. It is the entry condition that needs to be met before an object can transition from one to the another state. The exit condition characterizes the event under which an object transitions out of a state. The "accepted" order can become "the order for dispatching goods" if the event of its creation is finished.

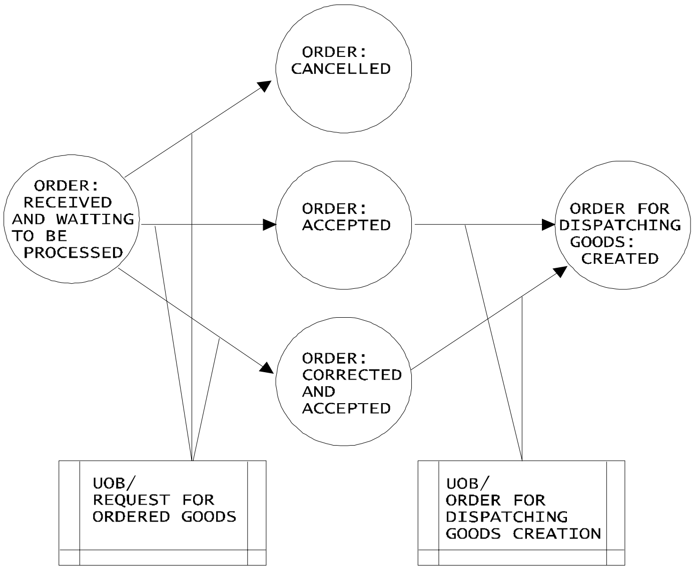

Figure 5: The example of "order" Object State Transition Network diagram

Application of simulation modelling requires defining the following elements: resource capacities, the time duration of activities, rules and probability of activities occurring, and the dynamic of entities coming into the system. Figure 6 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 (the value of the number t_t is generated by a random number generator). After the arrival occurs, one token is again deposited back to the “outside” place and another one to the “orders waiting” place. 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 for control” place.

Depending on the probability rule it fires one of the transitions: “order acceptation”, “order correction and acceptation” or “order cancellation”. If the “order cancellation” transition fires, the salesman becomes free. In the other two cases one token of type K is deposited in the “salesman ready” place, while one token of type (N) participates in the “dispatch order creation” transition. After the firing of this transition one token is deposited in the “waiting for dispatch” place. The “goods dispatch” transition fires if there is: (a) at least one token of type (N) in the “waiting for dispatch” place, (b) two tokens of type S in the “warehouseman ready” place and (c) at least one token of type V in the “forklift truck ready” place.

This transition is finished after t_f minutes and then two tokens of type S are deposited to the “warehouseman ready” place, one token of type V moves to the “forklift truck free” place, one token of type N (representing the order, the copy of the dispatch list and the goods) leaves the system, while one token of type D (representing the dispatch list) is deposited to the “waiting for invoicing” place. If there is a free accounts clerk (at least one token of type A in the “accounts clerk ready” place) the “invoicing” transition fires that completes the process.

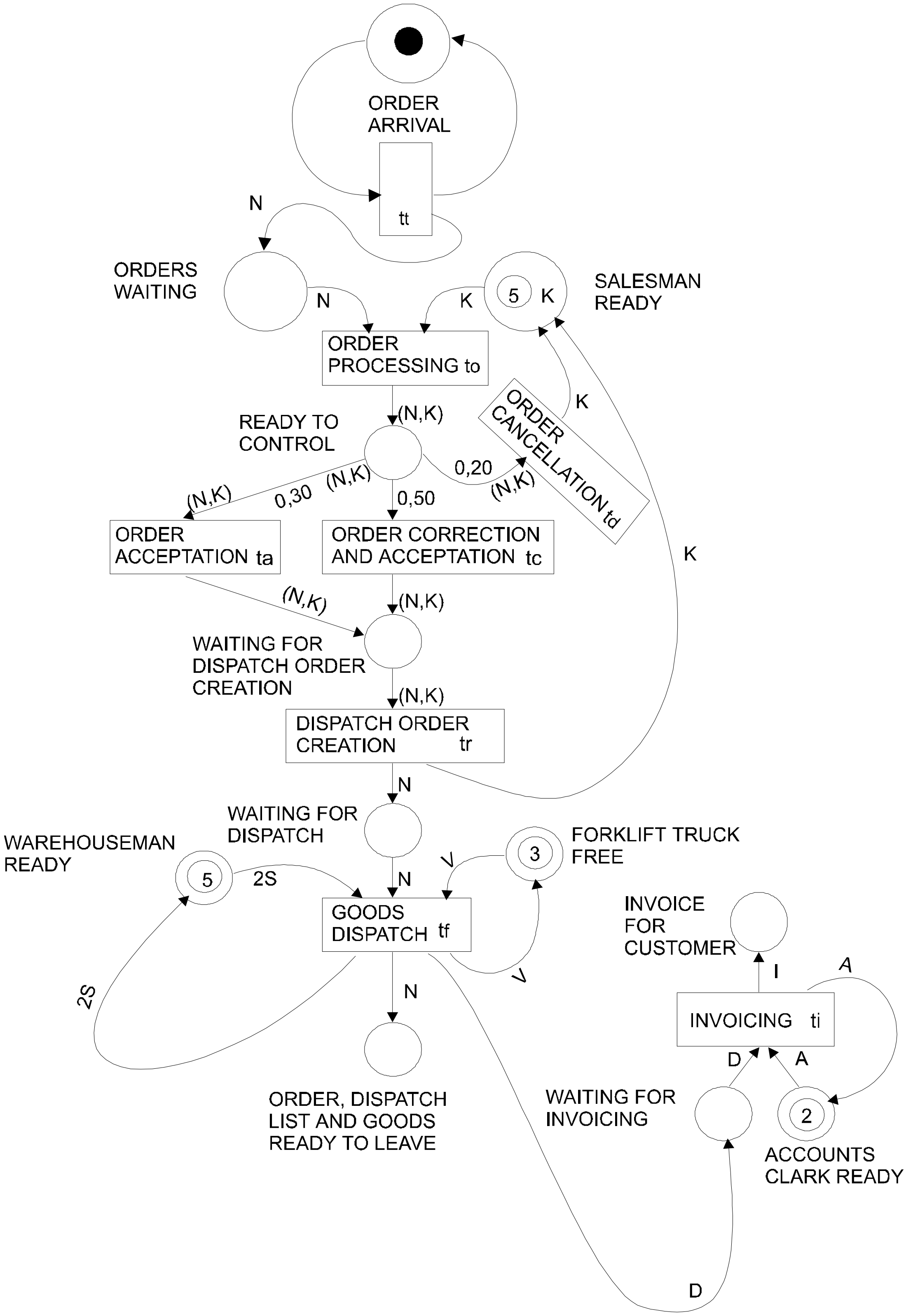

Figure 6: DES-net of the simple selling process

1. 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 modelling is a very effective tool for communication between the analyst and the participants of the processes. IDEF diagrams explicitly show activities. 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 modelling, such as queues, random behavior and process dynamics, but could provide the basic elements for simulation model development. Only two IDEF diagrams are presented in the paper: IDEF0 and IDEF3. Due to their similarities, but also the differences, they could be conveniently used together.

IDEF0 diagrams support the following functions:

- identifying basic elements of the process,
- identifying core processes,
- enabling hierarchical representation of system structure,
- helping focus attention on *what* happens in an organization.

IDEF3 diagrams accomplish the following:

- describing *how* process work,
- providing hierarchical representation and decomposition of the model,
- facilitating Top-down and Bottom-up modelling,
- providing both: “process-centered” and “object-centered” perspective,
- managing timing and decision logic of the process that is important for simulation modelling.

The example presented in Figure 6 shows that Petri nets are fairly simple since they use a limited number of symbols, but have large power of representation of system complexities. They can use hierarchical structures (each of the activities can be represented as a detailed simulation graph). Petri nets present activities and events by transitions while entities and resources are shown by tokens. There is a special symbol representing the queue, whilst control mechanisms are included by using conditions for transitions firing.

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 to increase service level, reduce total process cycle time and waiting time, reduce activity, resources and inventory costs, increase throughput.

Petri nets are "cost-effective" methods of exploring "what-if" scenarios quickly and finding an optimum solution to a problem because they are supported by a number of software tools that enable graphical representation of the systems by the executable models.

The presented modelling methods are compared in order to show their similarities and differences. Table 2 shows the comparison of IDEF diagrams and Petri nets.

Usage criteria	IDEF diagrams	Petri nets
Simplicity	Very simple, but not available for very complex models	Fairly simple, even for complex models
Power of representation of system complexities	Not very large	Very large
Hierarchical structure	Possible	Possible
Formalism	Not existing, or very small (elaboration)	Existing strong formalism
Standardization	Existing, very strong	Lot of versions, lack of standardization
Software	Numerous	Numerous

Table 2: A comparison of IDEF diagrams and Petri nets according to their usage criteria

The most important advantages of IDEF diagrams are the simplicity and the standardization that is very important for the communication between the analysts and the users. Petri nets have following advantages: very large power of representation of system complexities and strong formalism.

Petri nets are supported by a number of software tools that enable graphical representation of the system by the executable models, such as: Alpha/Sim (ALPHATECH, Inc.), Design/CPN (MetaSoftware Corp.), MOBY (Department of Computer Science, University of Oldenburg), XsimNet (Department of Computer Science, Abo Akademi) and many others (DAIMI, 2000). There are numerous software tools for both methods, but there is also a possibility of automatic translation of Petri nets into IDEF diagrams. This possibility is widely used in business process modelling, especially in information system modelling (Pinci and Shapiro, 1991; Pinci and Shapiro, 1993). Some of the software tools for translation of Petri nets into IDEF diagrams are: Design/IDEF, Design/CPN, WorkFlow Analyser and WITNESS model (Pinci and Shapiro, 1991; Shapiro, 1994; Christensen et al, 1997). IDEF3 based descriptions are used to automatically generate WITNESS simulation code in the target language using ProSim (Painter et al, 1996).

IDEF diagrams and Petri nets can also be compared according to their basic elements, as shown in Table 3.

Elements	IDEF0 diagrams	IDEF3 diagrams	Petri nets
Process	Yes (connections of activity models in a network)	Yes (connections of activity models in a network)	Yes
Activity	Yes (box)	Yes (box)	Yes (transition)
Entity	Yes, implicitly (data flow through activity network)	Yes, implicitly (data flow through activity network and elaboration description)	Yes (tokens)
Resource	Yes (bottom arrow)	Yes (bottom arrow and elaboration)	Yes (tokens)
Queue	No	No	Yes (places)
Start and termination of processes	No	No	Special symbols are not used, process starts when the conditions are fulfilled
Event	No	Implicate (state transition arcs in OST network)	Yes (firing of transitions and tokens in places)
Control mechanisms	Yes (top arrow)	Yes (top arrow and logic junction)	Yes (conditions, rules, arc guards and inscriptions)
Process dynamics and behavior	No	Yes but not completely (temporal relation links and junctions)	Yes, completely

Table 3: Comparison of IDEF0, IDEF3 and Petri nets elements

According to the comparison of IDEF diagrams we can conclude that IDEF3 diagrams are more powerful method with the basic elements for simulation modelling. 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 modelling because they capture all the elements important for process dynamics and system behavior presentation, like: firing conditions, entities arrival conditions, probability rules, random variables and queues.

Graphical symbols of IDEF diagrams can be translated into appropriate symbols for Petri nets (Table 4).

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 4: Translation of IDEF diagrams symbols in Petri nets symbols

Activities represented by rectangles (boxes) in IDEF diagrams can be represented as transitions in Petri nets. Links in IDEF diagrams are transformed into a combination of places and arcs in Petri nets. Text description of entities participating in the process shown in IDEF diagrams, can be represented as tokens (token classes) in Petri nets.

A decomposition of an IDEF diagram can be represented as transition in Petri nets. Junction boxes in IDEF3 diagrams become transition rules in Petri nets, whilst entity states in Object State Transition Network become places in Petri nets. State transition arcs in IDEF3 diagrams become events in Petri nets. Dynamics, concurrent processes and the impact of random variables are not captured by IDEF diagrams. On the other hand, Petri nets are able to represent these concepts by arcs inscriptions and transition rules.

2. Conclusions

This paper has demonstrated the usability of IDEF diagrams and Petri Nets for modelling business processes. A comparison of these methods was also provided.

IDEF diagrams advance business process modelling by:

- enhancing the effectiveness of extracting the knowledge and information from the users,
- facilitating the presentation of business process model to the users in order to get their validation and evaluation.

Due to their simplicity and understandability, it seems appropriate to develop IDEF diagrams during preliminary phases of business process modelling project in order to develop “AS IS” models. In later phases, when “TO BE” models are developed, IDEF diagrams could be simply transformed into Petri nets which adds formal semantic to the models. Simulating the effects of redesigned processes before implementation improves the chances of getting the processes right at the first attempt. The advantages of simulation modelling were demonstrated on the example of a retail system process model using Petri nets (DES-nets):

- Petri nets are fairly simple and easy to learn and use since they use a limited number of symbols, but have large power of representation of system complexities
- as a graphical technique, they enable the visualisation of the system being modelled,
- as a mathematical tool Petri nets can be used as analytic technique and can be applied to small models or submodels,
- Petri nets can handle concurrent, parallel, or asynchronous activities (the inability to handle these system complexities is the main disadvantage of many other simulation methodologies).

Multiple methods exist for BPR, but usually several different methods are used to perform more useful and efficient process modelling. Such an approach can support BPR projects and increase the chance for their success. This research reveals that IDEF diagrams and Petri Nets complement each other and that they should be used simultaneously for business processes modelling.

8. References

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