

Petri Nets and Business Process Management

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Foreword

The management of business processes comprises their planning, specification, modeling, analysis and computer-supported execution. Current trends in information technology such as workflow management systems or packaged software systems indicate the increasing importance of a systematic approach to business process management. Many graphical notations are in everyday use for business modeling purposes, usually resembling some version of data flow diagrams. Often, the lack of formal semantics and methodological support limits their computer-based analysis and execution. In most cases, the design and the improvement of business processes in industrial applications does with intuition and experience of experts only.

Petri nets have been in use as a graphical modeling language for more than 30 years. Mathematical analysis techniques allow for analytical verification of many relevant properties of systems' behaviour. Petri nets nevertheless are seldom used in business applications. Even the few commercially available Petri net based software development tools exploit Petri net theory to a very limited extend only. There is an apparent gap between practical needs of business process management in industry and theoretical investigations of Petri nets in the academic sector.

Recently, different variants of Petri nets have been suggested for various purposes in the context of business processes: As a reference language for the semantics of other, formal or semi-formal modeling languages, or as a means to compare and relate different modeling languages, or as a tool to execute process models, or in order to check reachability of distinguished states.

Central problems of this area include:

- Which specific requirements for modeling languages arise in the area of business process management and workflow management (related to office documents, organizational dependencies of tasks, cost, time and quality aspects)?
- How can the analytical and methodological potential of Petri nets be exploited for business process management?
- Which requirements are not met by classical Petri net models? Which extensions of the model are sensible or necessary?
- Will Petri nets eventually play a role for business process modeling which compares to today's role of the relational model for data modeling? Will there develop a normalizing theory for business processes similar to the normalization theory of relational data bases?
- May Petri nets formally link application oriented modeling languages to particular workflow programming languages?

This report contains abstracts from contributions to an IBFI Seminar held in Schloss Dagstuhl from July 6 to July 10, 1998. Moreover, it contains statements of three panel discussions. The seminar had more than 30 participants from various research and application areas, including Petri nets, business process modeling, workflow management, software and information system engineering. We like to thank all participants for coming and for contributing with talks and with lively discussions. We are most grateful to the people from IBFI for the administrative organization and for everything that makes Schloss Dagstuhl such a phantastic place for meetings like this one.

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1 Changing Workflows: On the Interplay Between Flexibility and Support

W.M.P. van der Aalst

Today's workflow management systems have problems dealing with exceptions, ad-hoc changes and structural changes of the workflows at hand. Solutions offered by groupware products are not a real alternative since they are weak in terms of control, support and management information. Changes can be classified as follows:

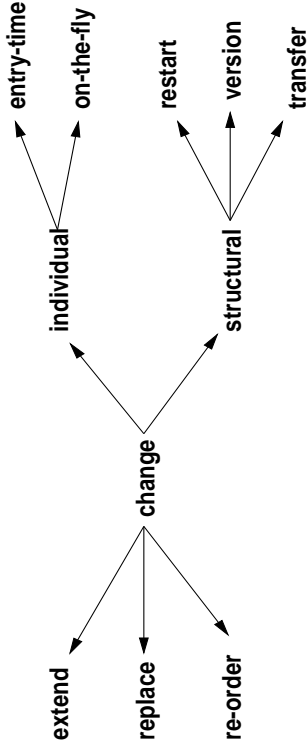


Figure 1: Classes of change

To be able to handle these changes and to bridge the gap between groupware and production workflow, several research groups are working on the problems associated to adaptive workflow. Adaptive workflow deals with all kinds of changes ranging from ad-hoc changes such as changing the order of two tasks for an individual case to the complete redesign of a workflow process as the result of a BPR project.

Typical issues related to adaptive workflow are:

- Correctness
What kind of changes are allowed and is the resulting workflow process definition correct with respect to the criteria specified?
- Dynamic change
What to do with running instances (cases) of a workflow whose definition has been changed?
- Management information
How to provide the manager with aggregated information about the actual state of each workflow process?

Taking these issues into account, a classification of the types of changes was presented. Based on this classification, potential problems are identified and pointers to solutions based on Petri net theory are given.

2 Information Models and Guidelines of Modelling (GoM)

Jörg Becker

Information models have two goals: to describe the domain (of discourse) as it is (descriptive modelling) and to create new processes and structures (prescriptive modelling). The rules that are given by the existing modelling methods (like Petri nets or Event-driven process chains (EPC)) are not sufficient to get "good" models. Therefore additional recommendations are needed to improve the quality of models. Some of these aspects were presented under the headline "Guidelines of modelling (GoM)". They were created according to the "generally accepted principles of accountancy" ("Grundsätze ordnungsmäßiger Buchführung", therefore "Grundsätze ordnungsmäßiger Modellierung (GoM)"). The six guidelines

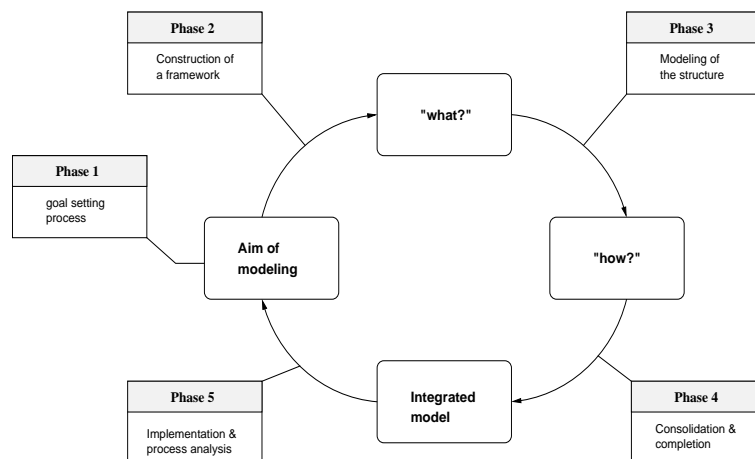


Figure 2: Procedure model for GoM

are: principle of correctness (syntactic and semantic correctness), principle of relevance (defining the goal of a modelling project (multiple perspectives!)), principle of economic efficiency (stop refining a model where the additional cost of refining the model any more is just equal to the additional benefit of doing so; try to obtain a specific model at the least possible cost (for example by using reference models)), principle of clarity (especially in the layout of models (e.g. no crossing lines) and in the use of specific symbols), principle of comparability (between two methods of modelling like Petri nets and EPC), principle of systematic design (consistency between two views on one domain of discourse like data view and process view).

The Guidelines of Modelling have to be embedded in a procedure model (see figure 2).

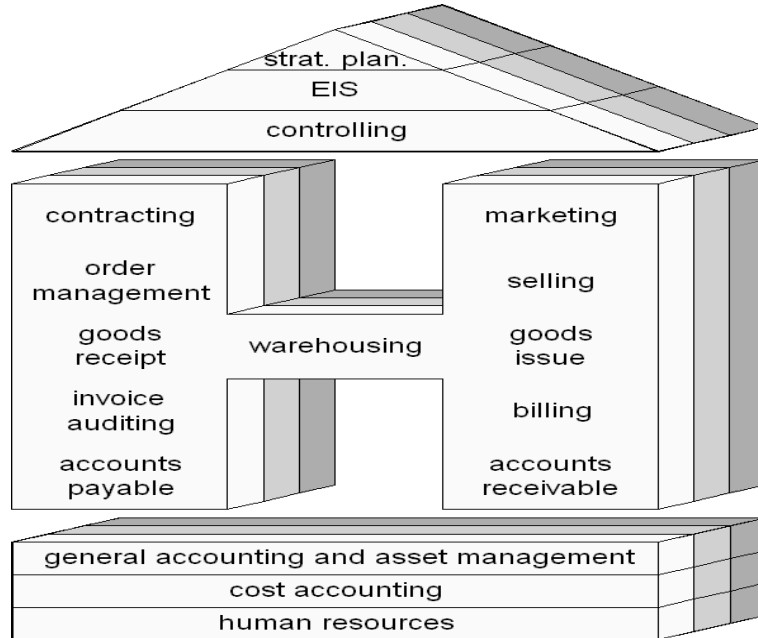


Figure 3: Framework for retail information systems

The necessity of a framework (phase 2) was discussed with regard to the framework for retail information systems.

3 Petri Nets and Business Processes

Anatol Holt

What are Petri nets? What are Business processes? I don't know; but I DO know what "organized human activity" is - since I developed a theory of organized activity (OAT) - and I am convinced that, whatever business processes may be, they ARE OA's. For my purposes therefore it is sufficient to consider how good Petri nets are for the representation of OA's. My conclusion: not bad and not good.

Reasons:

1. All OA's are performed in real time and real space. Petri nets make it hard to model either one.
2. In all OA's it is important to preserve/analyze/consider WHO does what. In Petri nets this link is hard to represent/analyze/consider.
3. In all OA's it is important to consider/analyze information, its flow, and its use in decisions. Petri nets lack the means.
4. All OA's are built on lumps of material intertwined with lumps of effort. These two basic aspects can be successfully mapped onto the circle and the square of which all Petri nets are composed.
5. Petri nets - whatever their disadvantages - have prospered in the world. This gives them a practical advantage - even for the representation and analysis of OA's - and therefore business processes.

4 Management-Oriented Models of Business Processes

Anastasia Pagnoni Holt

Every business involves a number of operations we might call processes: planning, production, marketing, bookkeeping, negotiations, etc. Today's business people specialize in managing a specific class of business processes, and increasingly rely on computer support. However, computer systems have to be based on some simplified model of reality. Setting up that model is the most relevant decision to be made, because it amounts to deciding which information will be taken into account, and what omitted, what questions will be answered, and by means of which algorithms, how you are going to deal with uncertainty, or imprecision, etc.

Several formal models of business processes have been suggested by applied mathematicians; each of them draws from a particular paradigm (the decision maker, the expert, the project manager, etc.), each of them yields a mathematical solution to a specific problem. Petri nets are reality models of quite different nature, because they do not originate from an exemplary problem story, but aim at representing real world systems of any kind, together with their working. Unfortunately, Petri nets lack much of the needed computational capability. Crafting methods from applied mathematicians onto Petri nets will help us designing computer support capable of answering meaningful management-oriented questions.

5 Computer Supported Reengineering of Business Processes

Kees van Hee

Based upon practical experiences in industry with modeling, analyzing and improving business processes two things are presented. First a framework for the business process reengineering-life cycle. This life cycle consists of the following steps:

- diagnosis (what is the problem, what are the goals for the (re)new(ed) process, what are the performance indicators, which values do these indicators have in the initial situation)
- redesign (modelling the existing situation, tuning the model using the measurement of the former phase, inventing improvements, modeling the new processes, verifying and validating them)
- reconstruction of information systems and human organization
- migration (conversion of systems and change management)
- operation (using the new process)
- back to diagnosis; leads to continuous process improvement

Only in the redesign phase (Petri net) modelling is an issue, but a very important one.

The second part of the talk was devoted to the support of modeling: the following functions can be distinguished; they are not available yet, but "wishes":

- model editing: not from scratch but using design patterns, not spending time to "derivable" aspects, like exceptions and rollbacks,
- model verification: incremental, during editing; maybe correctness by construction; translation of properties in "user language" to standard techniques like invariant analysis and reachability,
- model evaluation: analytical calculation of throughput times and resource utilisation; activity based costing,
- model improvement: according to transformation rules a process should be improved by a local search method.

6 Simple Workflow Models for Complex Business Processes

Giorgio De Michelis

Workflow management systems are considered a hot technology but they do not have up to now the diffusion of productivity tools, e-mail systems and/or groupware platforms. We think that this is due to the fact that existing workflow management systems, in general, do not offer all the services needed by the potential users. In particular, they do not have modeling capabilities adequately supporting exceptions, multiple views as well as static and dynamic changes.

In this talk, on the basis of my experience within the Computer Supported Cooperative Work field and within research projects on Cooperative Information Systems, I introduce the modeling environment of the workflow management module of the Milano system -a prototype of a CSCW platform we are developing at the Cooperation Technology Laboratory of the University of Milano.

The underlying idea of the Milano workflow management module is that workflow models must be simple and based on a formal theory, so that the various views, properties, changes can be computed when needed and not explicitly modeled. The modeling environment of Milano is based on a subclass of the Elementary Net Systems (they are acyclic and free choice net systems) and on its properties. An example, derived from a real bank procedure, is discussed in order to show how complex business processes can be effectively supported by our prototype.

7 An Architecture for Generic Market Services

Beat Schmidt

The division of labour in our economy is enabled by media considered as platforms which allow the exchange of information and goods for different purposes, following different protocols. These media are now in change, new infrastructures such as Internet provide the economy of the coming information age with a new global interactive medium.

The reengineering of business should not start with the processes of the old economy. The emerging generic market services for the different phases of the business transactions (information phase, negotiation phase, settlement phase) will offer a very powerful service infrastructure, comprising large parts of today's business processes.

On the other hand it also offers new possibilities for customer satisfaction, product bundling and for new products. So it's good to start with the consideration and design of the communities containing the customer, your business and the other players involved. These two layers - the community layer and the generic market services - provide the borderlines for process reengineering.

8 Computational Media - Metaphor, Model and Architecture

Ulrike Lechner

The notion of a medium is being changed and empowered by information and communication technology. The “new“ media distinguish themselves not only by the technology they are realized in, but in the means they provide to represent, process and organize the information they carry. We present a new metaphor of media, the computational media metaphor. Media are envisioned as spheres for agents and modeled as multi-agent systems. They are characterized by channels to transport information, agents to process information, logic to represent information and methods of information processing, an organisation with roles and protocols to describe the communities of agents and their interaction, and possible worlds as the semantics of the descriptions.

We employ Rewriting Logic and Temporal Logic to model those spheres. From this model we obtain an architecture for media. Reflection is essential for this model: agents are capable of reasoning about those media. This enables agents to act autonomously in their ”media world“.

9 Process Validation by Process Net Generation

Jörg Desel

The notion of a process net (a labeled occurrence Petri net) is discussed as a candidate for the proper representation of business process behaviour.

A process net represents a single concurrent run

- of some system/organization/model/mathematical structure
- on some abstraction level
- that has happened/might happen

In well structured business processes, concurrent runs can be specified by marked Petri nets (system nets). In weakly structured business processes, logic based or natural language based specifications are more appropriate. Mixtures of both approaches are possible and useful in practical examples.

The aim of the project VIP (University of Karlsruhe, University of Frankfurt/Main) is to use a Petri net specification for the analysis of the specified behaviour. To this end, we developed algorithms to generate process nets, visualize them to support validation, and analyze them with respect to invariant properties, causal chains and duties (a restricted kind of liveness properties).

10 Workflows, Scenarios, and Composition

Ekkart Kindler

Today, there is very little theory which supports the design of "good" workflow applications, i.e. workflow applications that do not deadlock or run into infinite loops. However, there is some theory which helps designing "good" single workflows, i.e. workflows that are "good" as long as considered in isolation. For example, there are the soundness criteria by Wil van der Aalst. Analysing a complete workflow application in the same way is too complex to be performed on today's computer systems.

In this talk, we will present some ideas which lift the soundness criteria from a single workflow to a complete workflow application. The basic idea is the specification of the interaction of different workflows by help of scenarios. Then, there are local criteria for checking global soundness of a workflow application. This way, the analysis of a complete workflow application may become feasible on today's computer systems. What is more, when the workflow application changes, it is only necessary to reconsider the soundness of the changed workflows.

11 Using Workflows to Structure Systems Based on Object-Oriented Coloured Petri Nets

Daniel Moldt

A central task of system specification is to build models to describe systems and their properties. Object-Oriented Coloured Petri Nets (OOC PN) are a technology which allows to combine object-orientation and Petri nets in a way that Petri net models are structured in an object-oriented manner.

In this talk the question of dynamic behaviour of a system based on objects is addressed in form of workflows which are represented by Scenario-Nets, a family of Petri net classes. A related method is presented that utilizes Scenario-Nets for modelling Business Processes. The fundamental idea is that the desired behaviour of a system (the set of all workflows) can be described by a (possibly large) set of different occurrence graphs (causal nets) as invented by Anatol Holt. The result when a model is built from scratch is often first described by a sequence of actions. To improve specification and to enable modellers to incorporate concurrency, causal nets are used for describing workflows. Similar workflows with the same structure but different data can be folded to coloured causal nets. A hierarchical concept is introduced to cope with large models. Finite repetition of parts of a workflow and inclusion of resources are covered by Process-Scenario-Nets, which can still be interpreted as sets of causal nets. Event- and Store-Scenario-Nets are further means to capture different requirements when keeping the state of the system or the incoming events stable and look at variations of the events or states.

Hierarchical coloured causal nets, Process-, Store-, and Event-Scenario-Nets, are folded to so-called Activity-Nets, which can be used to model Business Processes that cover a central issue of a company. A system is then nothing more than the set of all Business Processes.

The overall structure of a system is organized in objects, hence each action is assigned to one object. Object oriented coloured Petri nets (OOC PN) are used for the homogeneous structure of each Petri net model of an object. Within each object one can find several actions and thus several parts of different workflows. To couple object behaviour again objects are used. However, these objects are built to describe workflow integration in form of folded causal nets. The Scenario-Net hierarchy is reflecting the clear structure of the resulting workflows. Object interfaces are simple and resources should be kept local to objects to allow easier handling and verification.

Overall the dynamic behaviour of a system and all its objects can be constructed in a systematic and compositional way based on Scenario-Nets.

12 Action Logic for Modelling Workflows

Kurt Lautenbach

A logic is introduced whose basic formulae are elementary actions. The counterparts to interpretations and models of standard logics are processes. The counterpart of the logical conclusion concept is a fulfilling concept. A formula R (realization) fulfils a formula S (specification) iff every process of R is also a process of S. Direct and indirect proving is based on this definition and will be demonstrated by examples.

13 Workflow-Modelling in NetCASE

Thomas Marx

NetCASE is a PrT-net based CASE method for building information systems. For requirement engineering the iconic, graphical, semi-formal and animated APRIL diagrams are provided. These diagrams can be automatically transformed into incomplete PrT-nets for system specification. A CASE tool allows the immediate generation of Jxava prototypes including database scheme and access.

In a first approach the early phases of NetCASE are applied to workflow modelling. A workflow- and organisation-metamodel are defined, based on the WfMC "standard". Here, limited and special kinds of APRIL and object model diagrams serve for process and object modelling. These models can be analysed and later on be transformed into workflow scripts, according to the interface 1 description (WPDL) of the WfMC.

Lessons learned we are now discussing in how far the latter phases of NetCASE can be applied to workflow modelling in order to build independent applications. Workflow participants, applications and data seem to have particular demands on system engineering. The distribution of data and programs, the integration of applications and the communication between workflow applications are crucial. To some of these aspects the PrT net class of NetCASE proposes a feasible solution, separating and integrating control- and dataflow at the same time. Concerning the analysis of such workflow models we are currently studying the application of a particular action-logic in order to validate system properties.

14 Performance Analysis of Business Processes

Thomas Erwin

Because of their formal syntax and semantics Petri nets can be used for simulating the system that has been modeled with them. Since Petri nets are suitable for modeling business processes, Petri net models of business processes can be used for performance analysis of business processes. Within the the VIP-project (Karlsruhe/Frankfurt) a simulation concept based on partial orders has been developed. This simulation concept is used for a performance analysis of business processes in a 2-step approach:

1. The business process is modeled as High-level Petri net.
A number of partially ordered runs of the system are generated.
2. Time and costs are modeled for the business process model.
Time and costs are transferred to the partially ordered runs.
The runs are used for a performance analysis of the business process.

This approach is an efficient way to interactively examine the effects of different model values for time and costs on important performance indicators such as throughput time or waiting costs.

15 Guidelines of Using Petri Nets for Business Process Management

Christoph von Uthmann

Despite of their capacity and long, worldwide recognition Petri Nets are widely judged as too "complex" to be used in Business Process Management (BPM). Analysing this complexity perception there are identified several points which has to be worked on for making Petri Nets more accurate for the purposes of BPM. Within the framework of the Guidelines of Modeling (GoM), a project of the University of Münster, three major mutually dependent topics are focused on:

1. Towards a systematic and successive development of P/T-Net models a view oriented phase model will be presented. The views corresponding to the phase model are deduced from the Petri net specific understanding of processes. Within a view different aspects of describing process-structures and -instances are focused respectively.
2. Referring to analogies in the structures of Petri nets, which describe certain business and technology related occurrences, structural model blocks will be presented. It will be shown how Petri nets can be designed more efficiently and of higher quality by composing these model blocks. The concept of structural model blocks abstracting from a concrete operational context is set up complementary to existing model block concepts which depict concrete business processes. To make the application of the model blocks more operational they are assigned to the individual steps of the phase model.
3. In addition to syntactical aspects model conventions for Petri nets are given with the intention of achieving high semantic quality. The specific design principles are integrated in the phase model as well. To show how these concepts can be put into practice a case study of an extensive P/T-Net based simulation project for optimizing processes of a flexible manufacturing system will be presented.

16 Object-Orientation and Business Processes - An Approach for Integrating UML and EPC

Peter Loos

Object-orientation is the most common approach for implementing information systems. On the other side, methods to improve business strategies and business operation like business process reengineering are usually process oriented. Since requirements for information system implementation are derived from business analysis, an integration of process orientation and object-orientation is mandatory. Event-driven process chains (EPC) are widely used for modeling, analyzing and redesigning business processes. The resulting EPC models are used as a starting point for the development of information systems and for the definition of workflows. They can be applied for simulation and activity based costing. A major area of application is the implementation of standard software packages, because many vendors have documented their software's processes with EPCs. Since UML diagrams as the upcoming standard for object-oriented design do not yet cover all aspects required for the above mentioned application areas, an integrated approach is developed for describing the dependencies between event-driven process chains and UML diagrams. The dependencies are described by identifying equivalent elements in EPC and UML diagrams. A procedural approach is proposed that mainly applies EPC, Class Diagram and Statechart diagram.

17 BPM - A Management Perspective

Markus Nüttgens

Business Process Management is a complex task referring to the following aspects:

- Management of Organization
- Management of Technologies
- Management of Data
- Management of Resources
- Management of Products etc.

Therefore we need a framework dealing with views on business processes and the management life cycle of planning, controlling and monitoring business processes. The ARIS-Methodology provides a concept based on a meta-model that represents the meta-object needed to embed and integrate relevant methodological approaches. Therefore, the meta model is divided into the organizational, the data, the function and the product view. The views are linked by the control view. To use the methods stored in this meta-structure, we need some layer to link them to object instances. On the modeling level, we are describing and optimizing the process structures. On the planning and control level, we are scheduling and monitoring the processes and on the workflow level the processes are executed. On the application level, local support is implemented by application components.

18 Object-oriented Business Modeling

Joachim Wehler

We propose four principles for integrating object-oriented and process-oriented concepts into a unified theory of business modeling:

- Class (Attributes, methods, life cycle)
- Inheritance (Life cycle inheritance: van der Aalst, Basten 1997)
- Interaction (Coloured Petri Nets with colour sets, bindings and guard functions)
- Scaling (Abstraction morphisms: Lakos 1997)

We stress that we aim at less but powerful principles, that we set out to trace their consequences as far as possible and that we want to formalize them by mathematical concepts. In our opinion all of the four above principles can be applied to the business models of our customers from different companies. For future work, we consider it necessary to elaborate on the right definition of a morphism, in order to compare object-oriented business models on different levels of abstraction.

Principles of OO business modeling

- **Class**
 - Attributes, methods and life cycle
- **Inheritance**
 - Life cycle inheritance (van der Aalst, Basten 1997)
- **Interaction**
 - Coloured Petri Net
- **Scaling**
 - Abstraction morphism (Lakos 1997)

Figure 4: Principles of OO business modeling

19 Business Rules Layers Between Process and Workflow Modeling

Gerhard F. Knolmayer

Many methods for describing business processes have been developed, ranging from the mathematically well-defined, clear, but in communication with users only partially accepted Petri nets (PN) to less rigorous but in practice successfully applied "Event-oriented Process Chains" (EPC) [Reisig, 1992; Scheer, 1998]. PN use states and transitions, EPC employ events, functions and logical connectors (AND, OR, XOR) as base constructs.

In practice, the rather unprecise descriptions of business processes are usually not transformed in a systematic way to IS and workflow management systems (WFMS). A systematic refinement of models is a main paradigm in system development. Refinement concepts found thus far only limited interest in process modeling.

Business rules can be described according to the Event-Condition-Action (ECA) paradigm developed for active Database Management Systems. From this point of view, business rules trigger an action of the IS, send an alert to a human actor, or define the feasible space for human action. Therefore, the rules are not necessarily prescriptive but may also be semi-structured or "soft". Recently, the important roles of business rules in understanding real systems and, thus, in system analysis were stressed [Kilov/Ross, 1994; Herbst, 1996].

The main components of processes and workflows can be described by business rules. These components may be refined in several steps, leading from a process to a workflow description. The components of different granularity can be stored in a rule repository [Herbst/Myrach, 1997] which supports the "single point of definition"-concept. A prototype of a business rule oriented repository (BURRO) and a graphical interface has been implemented on top of the commercially available system Rochade by H. Herbst [1997]. PN can be derived as one possible view of such a knowledge repository [Herbst/Knolmayer, 1996].

Business rules can be regarded as one representation of a business process. Process models are eventually obtained by employing different modeling methods and tools in decentralized or virtual enterprises or along a supply chain; we propose to transform these models into a rule-based description of the business processes [Knolmayer/Endl/Pfahner/Schlesinger, 1997]. This business-rule-model may be stepwise refined until the system is represented by elementary business rules (figure 5). This rule layer should be sufficiently detailed to allow an automatic generation of specifications for the workflow management system.

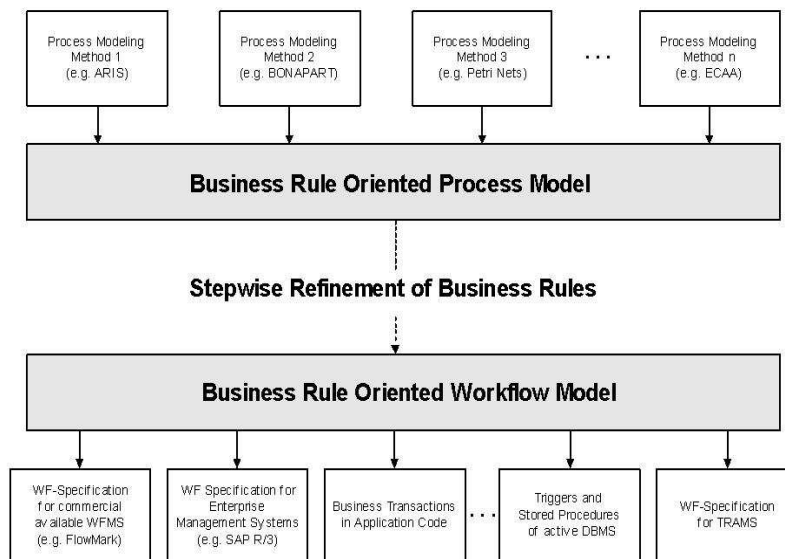


Figure 5: Business Rules as "missing link" between Process and Workflow Models

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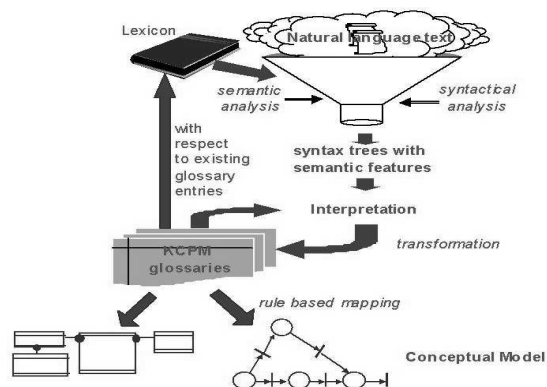
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20 Towards Business Process Modeling in KCPM

Heinrich C. Mayr

Software systems still suffer from deficiencies in the early phases of the system life cycle, i.e. the elicitation and analysis of user requirements and the transformation of these requirements to conceptual design. In my opinion, the main reason for that is the fact that the means usually used today for requirements analysis, i.e. methods of conceptual design like object oriented analysis (OOA, OMT, OOSE, UML), data modeling (e.g. ERM), dynamics modeling (e.g. Petri nets) are on a level of abstraction that is too high for the "requirements holder", i.e., the end-users. This is especially true for business people. We therefore propose to introduce, between natural language requirements elicitation and conceptual design, an intermediate step which we call "Conceptual Predesign".

The (semantic) model we propose for that step (i.e. KCPM: "Klagenfurt Conceptual Predesign Model") is lean and does not force the analyst to early design decisions like, e.g., if some real world aspect is to be modeled as a class or a value, respectively as an association or as an attribute. KCPM model is represented using graphical and glossary-like means, the latter being very appropriate for the communication between end-user and analyst, especially for validation purposes. Clearly, constructing a KCPM model by hand may become a voluminous task so that means and tools have to be provided for automating this task as far as possible. This is the goal of the NIBA project ("Natürlichsprachige Informationsbedarfsanalyse") which focuses both, the mapping from natural language requirements specifications to KCPM schema entries as well as the mapping of KCPM schemata to conceptual models. For the latter we use UML and, for dynamic modeling, Petri Nets.



21 Do Petri Nets Provide an Adequate Basis to Decently Model Business Processes?

Wolfgang Reisig

Every model of a piece of existing or planned real world emphasizes some aspects of reality and ignores others, according to the involved persons' interests. Do Petri Nets help to emphasize aspects that are important, and to ignore aspects that are irrelevant in models of business processes?

To tackle this question, we first discuss some essentials of Petri Nets: discrete events, passive and active components, explicit representation of the scope of a component, and redistribution of items as fundamental actions, instead of updating variables.

Those essentials offer the chance to model subtle relations among action occurrences, including separation and combination of causal and temporal order, explicit representation of points of choice, representation of resources that must be present without being consumed, and the distinction of independent and non-deterministically ordered action occurrences.

The essentials furthermore leave room to adjust Petri Nets to business processes, by identifying adequate net classes, equivalence notions, composition, inheritance and levels of abstraction. In fact, those constructs are presently being developed at several places.

22 Aspects of Modeling Business Processes

Andreas Dietzsch

Thinking about modeling business processes and Petri nets you can either ask "How do business processes fit to Petri nets?" or "How can Petri nets be used for business process modeling?". However, this does not only concern Petri nets, but also any other method used for modeling business processes.

To find an answer to the last question we have to apply the business process modeler's point of view. Doing this we find three relevant aspects:

1. The order of actions performed in order to reach a defined goal.
2. The objects which go into the product and so become part of the output of the process.
3. The subjects: the objects which create the output. These can be humans, machines or information systems.

Combining these aspects results in the question: WHY is WHAT created HOW by WHOM or WITH WHAT? To find out if or where a method can be used for modeling business processes we have to see if this question can be answered by the method.

23 Object-Oriented and Net-Based Modeling of Business Processes

Angela Mölders

The main problem concerning business process modeling results in meeting two different scientific areas: computer science and economic science. This is the source for many problems of misunderstanding. Computer scientists prefer formal methods and economic scientists demand clear and understandable models. That's why a business model never can be given in only one diagram but it will be a collection of different diagrams with a different level of formalisation and a different view onto the system. In my opinion object-orientation can solve these tasks.

Creating a business process model starts with a use case diagram. The use cases can be described in more detail by another use case-diagram or by activity diagrams. Activity diagrams are comparable to EPC and they are understandable to everybody and provide the problem-discussion between the modeler and the user. For a more detailed, formalised description of dynamic behaviour the Object Process Net (OPN) will be used. OPN was developed at TU Ilmenau as a special kind of object-oriented Petri net. We use it as an attachment to the UML for describing the dynamics of a system. Simulation of this OPN can be done. The static aspects of a system will be captured by a class diagram.

UML-based modeling requires tool support for ensuring the consistency between the several diagrams.

Additionally a set of modeling rules was established for modeling with activity diagrams. Transforming an activity diagram to a Place-/Transition net gives the possibility for checking whether the model meets these rules. This is done by reducing the PT-net by INA. If there are violations against the modeling rules the reducing procedure leads to typical fault structures. And if the related activity diagram to a PT-net is correct, this PT-net is a sound workflow according to the definition of van der Aalst.

24 Are Stochastic Petri Nets a Suitable Tool for Modeling Business Processes?

Helena Szczerbicka

Methods commonly used in modeling business processes do not incorporate quantitative analysis. Petri nets, very successfully used for analyzing qualitative properties, do not involve a notion of time. Thus analysis of quantitative measures such as performance of a system is not possible.

When having the goal to model business processes we have to define requirements on modeling capabilities of a modeling concept.

Let us present here the following view of business processes. It is a system characterized by a topology of resources (that can change upon time) and a flow of tasks that compete for resources and can be coordinated by some conditions. Let us incorporate the notion of time to the concept of Petri nets, as a stochastic variable for representing the firing time of a transition.

Then, using a mapping of the reachability graph onto an embedded Markov chain, a quantitative estimation of behaviour of the model becomes possible. Moreover, the model would capture the majority of properties of a business process. We can calculate the probabilities of markings (transient and stationary) and then derive several estimates for performance like the mean number of tokens in a place, mean waiting time in a place etc.

However, the quantitative analysis has to be done very carefully. Depending on the type of stochastic Petri nets it is not always possible to exploit the qualitative properties of an underlying Place-/Transition net.

25 Petri-Net-Based Business Process Management and the "Petri Net Baukasten"

Sabine Lembke

There are many different Petri net approaches and Petri net tools available today, making it difficult to find the appropriate Petri net approach and tool for a given purpose, eg. business process management.

This is where a model kit called the "Petri Net Baukasten" comes into play.

The purpose of the "Petri Net Baukasten" is to improve the understanding of Petri nets and their many variants, to enable the development of Petri net tools to support the application of Petri nets and their many variants, and to preserve the formal definition of the semantics of Petri nets and their many variants.

One important aspect of the "Petri Net Baukasten" is an assistance system designed to support application developers in finding the "right" Petri net variant and tool for specific application tasks.

26 Topic Session 1:

What is Business Process Management?

Armin Heinzl

Business:

Selling/producing superior products and services to customers.

Process:

Structured/causal arrangement of activities in order to fulfill certain business objectives.

Management:

The skill of identifying new opportunities or threats, allocating resources, handling disturbances, and motivating people to do the right thing.

Business Process Management:

An objective driven, continuous improvement of cross functional and/or inter-organizational business processes in order to gain competitive advantage.

Kees van Hee

A business process is a network of tasks that have to be performed on an object (called *order* or *case* or *product*) by a set of resources to meet the requirements of a client. Instead of one object we normally consider a stream of objects for a set of clients.

Examples are:

- the production of physical products like cars, bikes and food,
- the delivery of a service, like loan provision by a bank, treatment of a patient in a hospital,
- control over some other process.

Management of a business process can roughly be defined as „making the process work correctly, and efficiently”.

This task includes the following:

- definition or design of the process (strategic management),
- planning of the number of resources per type (tactical management),
- influencing the stream of objects (by pricing, policy, and marketing, also tactical management),
- assignment of resources to specific tasks (operational management).

27 Topic Session 2:

Important Application Problems of BPM

Markus Nüttgens

The question "What are important application problems of BPR?" can be discussed in two ways:

- Important application problems looking from a scientific point of view (development and application of methods and models that are formally correct),
- Important application problems looking from a business point of view (what are the "real" problems in the daily work).

Imagine, you would be a manager and responsible for your business processes. How will you have to invest your time and resources to solve application problems of BPR? I am sure, the answer and investment of resources wouldn't be the same as the way we are investing resources in BPR-research today.

For example, the following positions in the relation problem/investment could be the result:

Problem / Investment in %:	
20%	80%
formal methods	semi/informal methods
hard facts	soft facts
structured	unstructured
strategic	ad hoc
technical aspects	organizational/personal aspects
commitment of the management	commitment of the trade union
structure	flexibility
correctness	commitment
...	...

Maybe this simple example helps us to understand why BPR - even understood in a theoretical way - deals with a lot of application problems that are not covered by common research fields and topics until today. BPR is crossing borders and cultures, not only technical systems. Let's talk about those questions too!

Andreas Oberweis

In my opinion the most challenging research problem concerning the practical application of business process management is the development of a theory for

construction and use of reference models. Reference models describe (best xpractice) business objects and processes which are, e.g., supported by ERP systems, such as SAP R/3, BAAN IV, Oracle Applications etc. The introduction of an ERP system in an enterprise requires on the one hand an adaptation of business processes to the software (i.e. organizational change) and on the other hand a modification of the software system itself (so-called *customizing*). The optimization problem is to find a cost minimizing combination of organizational change and customization of standardized software package.

A theory of construction and use of reference models requires a certain degree of preciseness or formality of the underlying business model. Petri net theory could provide a formal basis for so-called delta-analysis which is a technique to measure the differences between two models with an appropriate metric.

Wil van der Aalst

What is the main problem in the WFM-domain?

The main problem in the workflow management domain are the systems. The workflow component in products such as WFM-tools, ERP-systems and CASE-tools is often weak and immature. The following problems are observed when evaluating a typical WFM-system:

- abstraction from states,
- real standards are missing,
- no verification support,
- hardly any performance analysis,
- problems w.r.t. exception handling and changes,
- limited flexibility,
- problems w.r.t. integration with DBMS and applications,
- performance and reliability of systems,
- systems instead of plug-in components,
- no support for multiple views on the workflow,
- no support for situational aspects.

The problems identified are a result of the absence of a generally accepted standard and the absence of a strong market leader. Nevertheless, it is clear that in the future these problems will be resolved because the functionality is generic and relevant.

28 Topic Session 3: Important Topics in Foundational Issues of Business Process Management

Jörg Desel

Compositionality

A model is compositional if the behavior of a composed system can be calculated from the behavior of its components, i.e., if $behavior(A \times B) = behavior(A) + behavior(B)$ for appropriate definitions of behavior and of the connectors \times and $+$. Compositionality is an essential feature for modular construction of complex systems.

There are numerous compositionality results for Petri nets, but none of them is generally accepted in the area of Business Process Management. It is not even clear how to identify components and their interfaces and how to specify the interface behavior of components.

Integration

There are at least three dimensions for integration:

- integration of formal and semi-formal description levels,
- integration of Petri nets and other modeling techniques on the same level of formality,
- integration of models for different aspects of a system, e.g. behavior, functionality, data, organization.

For each of these dimensions, no notion of integration is generally accepted.

Semantics and analysis of semi-formal models

For detecting design errors as early as possible, analysis and verification techniques should be employed as early as possible, i.e., as soon as some aspects of a system are formally modeled. Therefore, the meaning of the formal part of semi-formal models has to be precisely defined. Its semantics should not be confused with different semantics denoting different notions of behavior (such as sequential vs. nonsequential semantics).

Change management

Changing requirements yield modifications of system models. For large models it is unacceptable to repeat the entire process of design, analysis and validation after each minor change. More generally, a theory of configuration management is a demand for the design of industrial size system models.

Proper treatment of high-level Petri nets

The concurrent behavior of a high-level Petri net is usually defined via its unfolding to an elementary net. In particular, any structure of the high-level token objects is lost. For example, a Business Process might employ a letter with an address and a content. Assume this letter is modeled as a high-level token. Then only the address part is relevant for the navigation of this token through the net. An appropriate behavioral notion should abstract from the content and thus define high-level process nets. More generally, arbitrarily structured objects in Business Process Models have to be supported by Petri nets.

Combining runs and cases

Petri net theory distinguishes a system and its runs, both represented by Petri nets. Business Process Models often employ an intermediate notion which I would call a case. It represents the possible behavior of one task of a system. Typically, a case is represented by an acyclic net (like a run), but there might be exceptions for resources. In contrast to a run, the model of a case allows conflicts.

On a foundational level, one should carefully distinguish

- systems (represented by classical Petri nets with initial marking),
- runs (labeled occurrence nets, representing single runs of a system),
- cases (nets with input and output, often acyclic, representing the possible behavior of a single case),
- runs of cases = cases of runs (the actual behavior of a single case).

These views are related by appropriate morphisms.

Wil van der Aalst

One of the problems of the PM/BPM community is the limited transfer of knowledge to the application domain. Petri nets are applied within a limited number of enterprises. It is not clear how the use of Petri net theory in industry can be stimulated. In addition to this question there are some other open problems:

- Moving from syntactical correctness to semantical correctness:
Few tools and approaches allow for the verification of semantical correctness. A requirement for solving this problem is the development and selection of proper equivalence notions.
- Coping with second order dynamics:
How to transfer cases and how to generate useful management information.

- Bridging the gap between *what-if*-analysis and optimization:
Models from Operations Management either analyze a given situation or optimize a simplified model. Semi - automatic generation and analysis of models is needed.
- Infrastructure for capturing modeling knowledge:
The knowledge about modeling business processes is not stored in a uniform way. A unified way to store design patterns, reference models, and variant/generic models is needed to solve this problem.

29 Topic Session 4: Petri Nets and Other Models in Practical Use

Jörg Desel

The Petri Net Paradigm

Petri net models have a series of fundamentals. In turn all models based on these fundamentals can be called "Petri net based". What are the constituents of this "Petri net paradigm"?

- a graph (in a mathematical sense) and hence a notion of identity and of isomorphism,
- a graphical representation,
- local states (conditions, predicates, places, ...) and global states as derived concepts,
- local events (transformations, activities, ... of or on local states) and thus a notion of concurrency,
- a locality principle (dependency implies connectivity),
- synchronization can be expressed,
- alternatives, choice, nondeterminism can be expressed.

Many models follow this paradigm. Examples include various variations of Petri nets, but also Event-driven process chains and activity diagrams of UML.

There exist other paradigms such as object orientation, state based modeling, agent based modeling, ... These are orthogonal to the Petri net paradigm. The paradigms can be combined but in general combination does not yield a single model belonging to several paradigms at the same time but to different views.

Petri nets in a formal sense can be viewed as candidates for a logical layer between the conceptual layer of process models in practice (tool dependent) and the implementation layer of workflow languages (platform dependent), such as Turing Machines constitute a logical layer between program specifications languages at the conceptual layer and program languages at the implementation layer, or such as the Relation Model being a logical model between Entity Relation Diagrams and Data Definition Languages.

Michael Zapf

Object-oriented techniques are often used in practice for modeling of business processes in order to specify the requirements for a desired information system. The Unified Modeling Language (UML) has been established as a graphical standard in this field and includes many diagram types to describe static (class diagrams) and dynamic (use case diagrams, sequence diagrams, collaboration diagrams, statechart diagrams, activity diagrams) properties of the desired system.

Business processes are characterized by the interaction of many objects, so it is important to model this interaction with an adequate method. The activity diagram is the only diagram type in UML which allows for the representation of such interaction, but it has no formal semantics. On the other hand, there have been developed some formal approaches in unifying object-oriented techniques and Petri Nets and it would be very interesting to see whether they are more useful for modeling business processes than using the diagram types of the UML.