Application of Petri Nets to XPDL Workflow Optimization

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Abstract - This paper describes the conversion of XPDL workflows into Petri Network Modeling Notation. The result of such operation is analyzed for time consumption optimization. This shows how performing such operation results in tangible savings and economical benefits.

Keywords: Business Process, Workflow, XPDL, BPM, Petri Network, PNML, Petri Network Modeling Notation, optimization, P8 Business Process Management, P8 BPM

1 Introduction

This article presents the potential of the Petri Net model used for the optimization of business processes. There are several alternatives to model business processes. One modeling alternative is the Business Process Modeling Notation (BPMN).

For each company and organization, business processes and the related decisions are the key element which provides the momentum for their operations. The management of workflow and information within process paths has a major impact on the speed, flexibility and quality of decision-making processes. This is why the acceleration and optimization of processes is decisive for the success of any organization.

Processes involve people, systems and information. The maximum efficiency is possible only if all of these elements interoperate in an automated environment. Note also that optimized processes enable a faster response to the changing market situation and to new customers’ demands while guaranteeing compliance with applicable regulations. In short, better processes contribute towards continuous improvement of the efficiency of company’s operations, and therefore, allow gaining competitive advantage in the industry. One of the factors which make these tools increasingly popular is the tracking, analysis and simulation of processes. With the monitoring of work progress, with in-depth analysis of current and historical processes, and with the verification of changes to processes prior to their implementation in a production system, these functionalities guarantee more accurate business decisions. Additionally, they enable fast implementation of best business practices, guarantee unified processing, and reduce the total cost of system ownership with reusable process definitions.

Usually, such business processes are developed with a graphical tool which allows easily defining, designing and administering business processes for business and IT users. It offers a powerful process definition environment enabling accurate implementation of complex, interrelated processes with broad functionalities.

The aforementioned advantages of Business Process Management (BPM) are widely spoken of, but not enough attention is paid to the optimization problem. Today’s tools offer the functionality of business process optimization. However, expert knowledge is required to use them efficiently. With their experience backed up by software-based simulations, the consultants who operate such tools are able to specify the way of optimization of the process concerned. The weakness of the BPM description language is the inadequate description model.

Only few business process description models enable the use of process map optimization methods and analyses (process paths in the form of a graphical map) to improve the timeliness (accelerate), to ensure the optimum use of resources, or to save money.

The apparatus for modeling communications with automata [1], introduced by Carl Petri in 1962, is a tool perfectly suited for the optimization of business processes. In the simplest version, the Petri Net comprises of “places,” “transitions,” and directed arcs. Such a net may only be used to describe a system as a static connection of possible states. The graphical representation of the net is a bipartite graph in which the nodes represent places (signified by circles) and transitions (signified by bars).

Figure 1. Petri Net diagram
The Petri Net is a 4-tuple \( C = (P, T, I, O) \), where \( P = \{ p_1, p_2, \ldots, p_n \} \) is a finite set of places, \( T = \{ t_1, t_2, \ldots, t_m \} \) is a finite set of transitions, \( I : T \rightarrow P^* \) is the input function, and \( O : T \rightarrow P^* \) is the output function. The sets of places and transitions are disjoint: \( P \cap T = \emptyset \).

The value of the \( I (t_j) \) function is the collection of input places of the \( t_j \) transition.

The # \( (p_i, I(t_j)) \) notation means the number of occurrences of the \( p_i \) place in the \( I(t_j) \) collection.

The value of the \( O(t_j) \) function is the collection of output places of the \( t_j \) transition.

The # \( (p_i, O(t_j)) \) notation means the number of occurrences of the \( p_i \) place in the \( O(t_j) \) collection.

The nodes of the graph are connected with directed arcs so that no two places and no two transitions are connected directly. The reachability tree, the matrix equations and the invariants of places are the methods of Petri Net analysis which enable optimization of business paths.

2 Business process optimization

2.1 Definition of the workflow path

The example of the path optimized in this article is a sub-process of the map of handling a settlement request supported by BPM tools. Figure 2 below shows a part of the business process handling procedure: the presented sub-process of handling the electronic request comprises of six steps. Some of them are performed automatically.

Figure 2. Diagram of the process map with general properties of a process step

(e.g. the Auto-completion of Data where the connection with customer’s external systems is established to retrieve the information, while others are handled manually by specific actors [process participants]). The BPML model significantly differs from the mathematical model. It focuses on the definition and description of tasks assigned to participants, and on the making of appropriate decisions. However, that model does not enable the exact analysis in terms of the optimization of resources, time or costs involved in performance of the concerned process. On the presented sub-map, the first step (Submitting the Request) is performed by the Office participant. The task of that participant is to complete the corresponding process data and to transfer the current instance of the process to the next step.

The data necessary to handle the business process, and the logic of transitions between specific steps, are defined with task flow variables.

Figure 3. The definition of process variables, process properties available in the specific step, and definitions of conditional transitions between the steps

2.2 Conversion to the Petri Net model and optimization

The graphical map of the process is stored as a definition in an XML file. The open structure of the standard of the description of business paths allowed for the construction of a tool which translates the aforementioned structure to PNML (Petri Network Modeling Language). That tool uses the intermediate form which provides a metadata description of the map of the source business process.

Figure 4. Intermediate form of the source map of the process

The conversion of information on steps, transition sequence, resources and variables included in the BPM map resulted in an equivalent notation based on Petri Nets. The basic PNML model was used [10].
Article includes tool for conversion between XPDL maps created in P8 Process Designer and PNML languages. Maps saved in Petri Network Modeling Notation could be open Yasper editor (one of the most popular Petri Network graph editor www.yasper.org).

The mathematical model developed as described above was subject to a simulation of flow enabling the optimization of transitions. The experiment resulted in a Petri Net map presenting the optimized BPM model:

Figure 5: Process map presented in the PNML Petri Net notation

Tools like Yasper gives powerful capabilities of simulation and optimization of Petri graph. The following property was used in the example analyzed above:

1) a1 -> a2, p* output parameters a1, p* input parameters a2
2) a2 does not depend on p*

a1 -> a2, a1||a2

The program analyzed the relationships between specific steps. It has examined the dependencies between the sequence of steps and the data necessary for the performance of tasks specified in various steps, and identifed the steps which may be performed in parallel. BPML imposes a specific manner of acting/thinking of the process. The conversion of the map to the Petri Net model allows for optimization of the business process. The resulting optimization of process timeliness provides measurable business advantages (acceleration, economies).

3 Experiments

The translation of the original process map to the equivalent PNML-based Petri Net model enabled performance of a complex analysis to determine the process steps which may be handled in parallel [11, 15]. The optimization algorithm was as follows:

Arranging the elements into groups,
4 Conclusions

The experimental research presented in this article demonstrates that the Petri Net model may be efficiently used to map business processes used in BPM software, and to subsequently analyze and optimize these processes. Previous scientific studies on the aforesaid matter included only a few theoretical attempts to translate some processes described in BPMN 1.2 to the Petri Network Modeling Notation (PNMN) which corresponds to the standard Petri Net model. This document demonstrates the feasibility of the translation of process maps to the Petri Net model, and of the sophisticated optimization of business processes.

The paper presented an idea for applying Petri Network based optimization to business process designs. By developing a formal business process model and orienting it to Petri Modeling Notation, the generation of optimized business process map was facilitated and demonstrated using the real example. What make the business process optimization problem distinctive is its highly constrained nature and the fragmented search space that has a significant impact on locating the optimum solutions. It is shown that state-of-the-art Petri Network based optimization algorithms produced satisfactory results by generating and preserving optimal solutions on process designs. That provides an adequate alternative optimized process designs for the business analyst to decide the trade-offs between the different objectives. The results presented here are indicative and encouraging for further research in the area of business process optimization.

This series of articles presented approach differs significantly from the typical process optimization model. As opposed to the traditional approach of optimization, according to which the expert-matter knowledge is necessary - methods described in the articles is more automatic. With the use of traditional optimization methods it could bring significant values to business.

5 References


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