RESEARCH ON WORKFLOW MODELING BASED ON COLOURED PETRI NET

Zhang Liang, Yao Jiayi
School of Economics and Management, Beijing Jiaotong University, Shang Yuan Cun no.3, Haidian District, Beijing, China

Zhang Yingrui
School of Economics and Management, Beijing Jiaotong University, Shang Yuan Cun no.3, Haidian District, Beijing, China

Keywords: Workflow, Petri Net, Workflow Modeling.

Abstract: Petri as an effective tool for modelling and analyzing processes, which is widely used in the field of workflow management. This paper introduces the correlation theory of the high-level Petri net with colour extension and brings forward a workflow modeling method based on coloured Petri net. With the thought, a workflow model of training institution management is made at last.

1 INTRODUCTION

During the 1990s, workflow management technology was on the rise, which is widely used in business management with Business Process Reengineering (BPR). The crucial point about the workflow management is workflow modeling, which is theorization and abstraction of business process. It is the mirror of description of business process in computer or system, especially a clear understanding and awareness. Actually, it is the basic function of Workflow Management System.

There are several currently proposed methods of workflow modeling. With the formalized system and exact definition, Petri net is widely used in the practical modeling.

2 BASIC CONCEPTIONS OF WORKFLOW

The principle workflow originated from the field of production organization and office automation, which is brought up aiming at constant rule and operating mechanism in production and work (Sheth, 1993). It is exact and convenient to decompose a work in operating into many tasks and roles exerting workflow, while monitoring and constraining every execution of tasks. So quality and efficiency of company management should be increased.

Workflow Management Coalition was founded in 1993, which marks that workflow technology will have a unified standard and enter a relatively mature step. WFMC suggest a definition of workflow is a computerised facilitation or automation of a business process, in whole or part (David Hollingsworth, 2001). It is concerned with the automation of procedures where documents, information or tasks are passed between participants according to a defined set of rules to achieve, or contribute to, an overall business goal.

3 BASIC CONCEPTION OF PETRI NET

Petri nets were devised in 1962 by Carl Adam Petri as a tool for modelling and analyzing processes. One of the strengths of this tool is the fact that it enables processes to be described graphically, and we can use it to present workflow processes in an accessible way. Despite the fact that Petri nets are graphical, they have a strong mathematical basis. Unlike many other schematic techniques, they are entirely formalized. Because of this formal basis, it is often possible to make strong statements about the properties of the process being modelled. There are

Liang Z., Jiayi Y. and Yingrui Z..
RESEARCH ON WORKFLOW MODELING BASED ON COLOURED PETRI NET .
DOI: 10.5220/0003593304230426
In *Proceedings of the 13th International Conference on Enterprise Information Systems* (NMI-2011), pages 423-426
ISBN: 978-989-8425-53-9

also several analysis techniques and tools available which can be applied to analyze a given Petri net.
Over the years, the model proposed by Carl Adam Petri has been extended in many different ways, so that it is possible to model complex processes in an accessible way.

3.1 Classical Petri Net

A Petri net consists of places and transitions. We indicate a place using a circle. A transition is shown as a rectangle. Figure1 shows a simple Petri net, consisting of three places and three transitions.

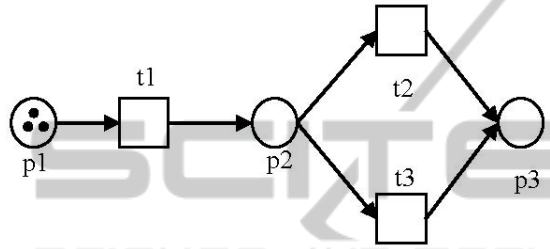

Figure 1: Classical Petri Net.

Places and transitions in a Petri net can be linked by means of a directed arc. There are two types of arcs: those that run from a place to a transition and those that run from a transition to a place. Arcs from a place to a place or a transition to a transition are not possible.
Based upon the arcs, we can determine the input places of a transition. A place p is an input place for a transition t if and only if there is a directed arc running from p to t. Similarly, we can determine the output places of a transition. A place p is an output place for a transition t if and only if there is a directed arc running from t to p. As it happens, in figure 1 each transition precisely has one input and one output place.
Places may contain tokens. These are indicated using black dots. In figure 1 the place claim contains three tokens. The structure of a Petri net is fixed; however, the distribution of its tokens among the places can change. The transition record can thus take tokens from the claim input place and put them in under consideration. We call this the firing of the transition t1. The regulation which the firing of the transition must obey is that the state of a Petri net is indicated by the distribution of tokens amongst its places (Aslas, 1998). A transition may only fire if it is enabled. This occurs when there is at least one token at each of its input places. The transitions are ready to fire. In figure 1, only the transition t1 is enabled.

As transition fires, one token is removed from each input place and one token added to each output place. The change from Figure1 to Figure 2 shows the effect of t1 firing.

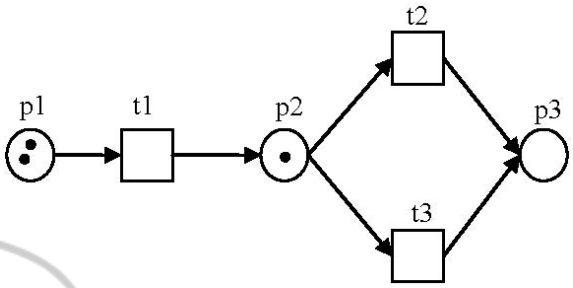

Figure 2: the Petri net after t1 fires.

Therefore, the classical Petri net can be defined to the mathematical structure as follow.

Definition 1: Quadri-tuple PN = (P, T, F, M_o) is a Petri net only if

(1) $P \cap T = \emptyset$
(2) $P \cup T \neq \emptyset$
(3) $F \subseteq (P \times T) \cup (T \times P)$
(4) $dom(F) \cup cod(F) = P \cup T$, when
$dom(F) = \{x \mid \exists y:(x, y) \in F\}$
$cod(F) = \{y \mid \exists x:(x, y) \in F\}$
(5) $M: P \rightarrow T$, M_o is the initial token.

3.2 Coloured Petri Net

Tokens of Petri net are used to model a whole range of things. In one insurance claim model they can represent insurance claims, in vehicle production model can the state of manufacturing. However, in the classic Petri net it is impossible to distinguish between two tokens: two in the same place are by definition indistinguishable. Aiming at this problem, colour extension is bought to distinguish the tokens in places (Jensen, 1996).
For example, tokens for students have an age value. Because of different value, the token can be distinguished of a certain degree. This method of valuing tokens is similar to giving different colours. So we named this extended Petri net as coloured Petri net.

Coloured Petri net can be defined to the mathematical structure as follow.

Definition 2: Six-tuple CPN = （P, T, C, I, O, M_o）is a coloured Petri net only if

(1) $P \cap T = \emptyset$
(2) $P \cup T \neq \emptyset$
(3) $C = \{C(p), C(t)\}$
(4) $\overline{P} = \{<p, c> \mid p \in P, c \in C(p)\}$

(5) $\overline{T} = \{<t, c> \mid t \in T, c \in C(t)\}$

(6) $I = \overline{P} \times \overline{T}$, $O = \overline{T} \times \overline{P}$

4 WORKFLOW MODELING BASED ON COLOURED PETRI NET

With securities training institution application is below example undertake demonstrative, which focus on tracking the progress of the students training, teacher allocation and student test.

New students register with the training institution. A registered student takes one or more securities lessons followed by an examination. Each securities lesson has a beginning and an end. Instructors give securities lessons. The driving school has five securities. Each securities lesson is followed by either another lesson or an examination. The examination has a beginning and an end and is supervised by an examiner. In total there are ten examiners. For the outcome of an examination there are three possibilities:

(1) The student passes and leaves the driving school.
(2) The student fails and takes additional lessons in order to try again.
(3) The student fails and gives up.

Students must takes ten lessons before taking the exam and people will drop out if they fail three times.

The workflow model of the securities training institution is shown in figure 3.

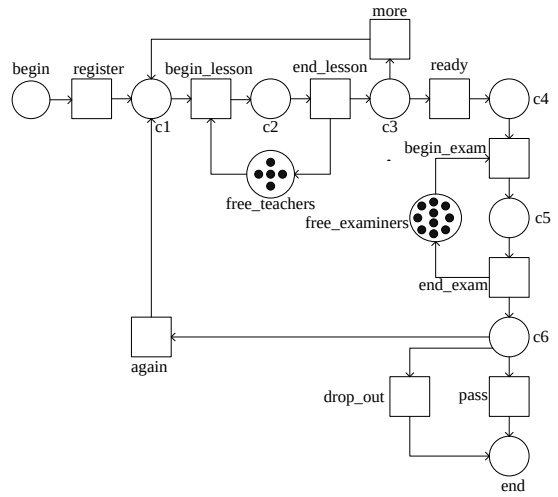

Figure 3: The workflow model of the securities training institution.

Based on the model in figure 3, we make colour in the tokens. There is a cc= (token, name, age, gender, nof_lessons, nof_exams) in place begin, register, c1, c2, c3, c4, c5, c6 and end, which is mean to a student who have id, name, age , gender, class-times and exam-times. For example, there is a new student named Jack, who is an eighteen boy and has no lesson and exam.

Nof_lessons and nof_exams are the key points to this model. The last rule of the training institution is be clearly described in the model with class-times and exam-times.

Transitions in the training institution model are defined as follow.

(1) register：nof_lessons = 0, nof_exams = 0
(2) More and ready are integrated to more1.As the figure 4 shows, when nof_lessons < 10，make a token in c1or in c4

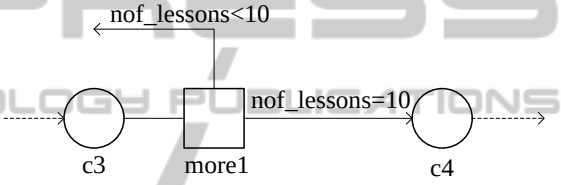

Figure 4: More and ready are integrated to more1.

(3) end_lesson：nof_lessons = nof_lessons+1
(4) end_exams：nof_exams = nof_exams+1
(5) again：nof_exams < 3

The result of the color extension is that, in contrast to the classic Petri net, the graphic representation no longer contains all the information. For each transition, the following factors must be specified:

(1) Whether there is a precondition. If there is a precondition, then this must be defined precisely.
(2) The number of tokens produced per output place during each firing. This number may depend upon the values of the tokens consumed.
(3) The values of the tokens produced. This, too, may depend upon the values of the tokens consumed.

Depending upon the objective for which the Petri net has been produced, the transitions are specified by a piece of text, a few lines of pseudo-code, a formal specification, or a subroutine in a programming language.

5 CONCLUSIONS

Classical Petri net is an effective tool to describe synchronism, asynchronism and distribution in process, and it can make control and constraint to resource allocation in workflow. However, it is complex to model the complex-property workflow by Classical Petri net, while coloured Petri net can handle this situation, particularly in distinctions among roles and organizations. The workflow model based on coloured Petri net has better ability of description and analysis. So, there is great theoretical and realistic significance in research on workflow modeling based on coloured Petri net.

REFERENCES

David Hollingsworth, 2001. The Workflow Reference Model. Document Number WFMC – TC – 1003, *Document Status – Issue 1.1*.

W. M. P. Vander Aslas, 1998. The Application of Petri Nets to Workflow Management.WFMC, 2003. *The Journal of Circuis, Systems and Computer*.

Yan. Yuhong, Bejan. Alex, 2002. Modeling workflow within distributed systems. *Proceedings of the International Conference on Computer Supported Cooperative Work in Design.*

Hsu. Chih-Chiang, Huang. Kuo-Chan. 2011. Online scheduling of workflow applications in grid environments, *Future Generation Computer Systems.*

Song. Xudong, Dou. Wanchun, Chen. Jinjun. 2011. A workflow framework for intelligent service composition. *Future Generation Computer Systems.*

A. Sheth, M. Rusinkiewicz, 1993. Transactional Workflow and Bulletin of the Technical. *Committee on Data Engineering.*

Salimifaard k., Mike Wright, 2001. Petri net-based modeling of workflow system. *European Journal of Operational Research*.

Prilr C., 2002. Workflow and process management, *Workflow Management Coalition Handbook.*

Tadao Murata, 1989. Petri Net: Properties Analysis and Applications, *Proceedings of the IEEE.*

K. Jensen, 1996. Coloured Petri Nets. *Springer-Verlag.*