Concurrency and Collision Workflow Model Based on Petri Net in Electric Power Monitoring System

Weicheng XIE
School of Electrical and Information Engineering
XIHUA University
Chengdu, China
e-mail: scxweicheng@yahoo.com.cn

Yi XIE
College of Computer and Information Science
XINAN University
Chongqing, China
e-mail: benden@swu.edu.cn

Abstract—**Electric power monitoring system is a complex system, its workflow model is an important task in the system design. The paper provides an approach to solve the concurrency and collision problems using Petri net as workflow model tools in the system. In support of the system, this paper makes the relevant definitions, and takes example for the concurrency and collision workflow model application, and shows a relevant workflow model based on Petri net. Moreover, validate the correctness of the collision model.[*]**

Keywords- Electric Power Monitoring System; Workflow; Petri net; Concurrency Model; Collision Model

I. INTRODUCTION

In the design of the electric power monitoring workflow system, it is greatly difficult to describe condition and embranchment logic of workflow. Accurate description of workflow and establishing correct workflow model is the key to the design of such systems.

Petri net is a graphics-oriented modeling tool and is defined with mathematics strictly. It is one of the most potential modeling tools. Via graphic description, Petri net can be used to solve complex problems encountered in the development of system easily. It can be used for the description and modeling of the characteristic systems with concurrence, asynchronism, distribution, uncertainty etc. Workflow Network based on Petri net is dedicated to the modeling of business processes, so it is a special Petri net.

We successfully solved the concurrency and collision problems encountered in the design flow by using workflow network as the analysis tools for system. It is greatly significant for us to design the systems with complex workflow.

II. THE MONITOR SYSTEM WORKFLOW AND PETRI NET

The electric power monitoring system is a complex system. The workflows of the system are Sequence, concurrency, or collision. They involve three kinds of active bodies: electric power monitoring pots, electric power monitoring organization unit and electric power responsible departments for the work.

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A. Petri net

Petri net is a directed graphics involves place and translation two nodes. In the directed graphics, the arc is used to connect the place and translation, the token distributed in the place decide the state of the system, the power function on the arc express the change about the amounts of the relevant resource when the translation occurs. In the paper, we use circle to denote the place and rectangle to denote the translation.

B. Workflow

Workflow is the formalization description of business processes which involves the workflow logic describing the dependence relation among tasks and workflow semantic expressing the meaning contents on the logic. There into, workflow logic is used to describe the dependence relation among the tasks in business flow but workflow semantic is used to clear up the collision in the workflow logic and decide the real route for case.

In the workflow logic, we will use these configurations as follow modeling system:

- Serial device
- Forked device: it includes forked selection and forked parataxis.
- Syncretic device: it includes syncretic selection and syncretic parataxis.
- Mixed device: it includes twin selection, syncretic selection, selected parataxis and twin parataxis.

III. THE DEFINITIONS OF WORKFLOW

Based on the general business management workflow, we give the relevant definitions as follows.

Definition: Known a business management system, $\sum$= (P, V, T, F, K, W, R, Wr, MT, M0), if it satisfies the conditions below, we will call it workflow semantic:

$$P= (p1, p2, ..., pn) \quad (1)$$

P is the place set, each place represents one kind of resources in the system;

$$V= (v1, v2, ... ,vn) \quad (2)$$

v□V:| r(v)| >1□M0(v)≠ψ w(v)=ψ, ψ is the general default value. V is the dominant variable collection of B-

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form, B-form is a form which is transmitted in the system, like requisition, archives and so on;

T= (t1, t2, ..., tn) (3)

T is the translation set, each translation represents an activity or a task in this system;

P□T□V≠Φ □ P∩V=Φ □ P∩T=Φ□ V∩T=Φ;

F□ P×T□T×P (4)

It is the flow relations dom(F) □cod(F)=P□T;

K: P→N□{w} (5)

It is called capacity function on ∑;

W: F→N (6)

It is called weight function on ∑;

R is read relations on ∑. r□R, r□D1×D2 (7)

dom(r)={d1| d2□D2:(d1,d2) □r}

cod(r)={d2| d1□D1:(d1,d2) □r};

Wr is called write relations on ∑; (8)

MT= <Mtid, S, Ff, Fb, Bid, E, body> (9)

MT is the translation symbol set. Among them, Mtid is the only number express translation symbol, S expresses the state of translation, Ff and Fb respectively is the input flow function set and the output flow function set of the translation, Bid is the form symbol which the role processes, E is an expression which translation involves, Body is the assignment statement which translation involves;

S= {S0, S1, S2, S3, S4}

S0 is the action states set, S0 expresses the action is at ready, S1 expresses the action is running, S2 expresses the action is finished, S3 expresses the action is suspended, S4 expresses the action is exceptional; S0 is the initial state, S2 and S4 are ending state;

B= <Bid, Ver, Datalist>

B is the form set. Among them, Bid is the only symbol number of B, Ver is the edition number of B, Datalist is the relevant data list of B;

M0 is the initial symbol on ∑; (10)

Restricted in the length, the translation rule and translation consequence definition to be see in [1].

IV. Establishing the Workflow Model

In the design of complex workflow management system, the core is to drive and manage the complex workflow, these flows may change at any moment at actual operation, they can change along with the application scene (for example electric power monitoring pot, electric power monitoring plan so on). The randomness increases the difficulty in system design, but workflow technology can solve this problem well. We take the electric power monitoring system as the example to establish the workflow model for the system.

In the electric power monitoring system, it mainly involves three kinds of active bodies: electric power monitoring pots (namely enterprise or individual), electric power monitoring organization unit (mostly is electric power corporation or transformer substation), electric power responsible departments for the work (specialized electric power manage government department and so on). In the following description, we will use A, B and C to replace them separately. The electric power monitoring system is complex, Some workflow of A, B and C are sequence, some workflow of A, B and C are concurrency, and some workflow of A, B and C are collision. In the practical development of the electric power monitoring system, about percentage of the workflows is as follows table I.

TABLE I. Workflow of Electric Power Monitoring System

Workflow	Monitoring pots (A)	Monitoring organization unit (B)	Responsible department (C)
Sequence	80%	20%	10%
Concurrency	10%	50%	50%
Collision	10%	30%	40%

The x % shows percentage of every kind workflow in active bodies

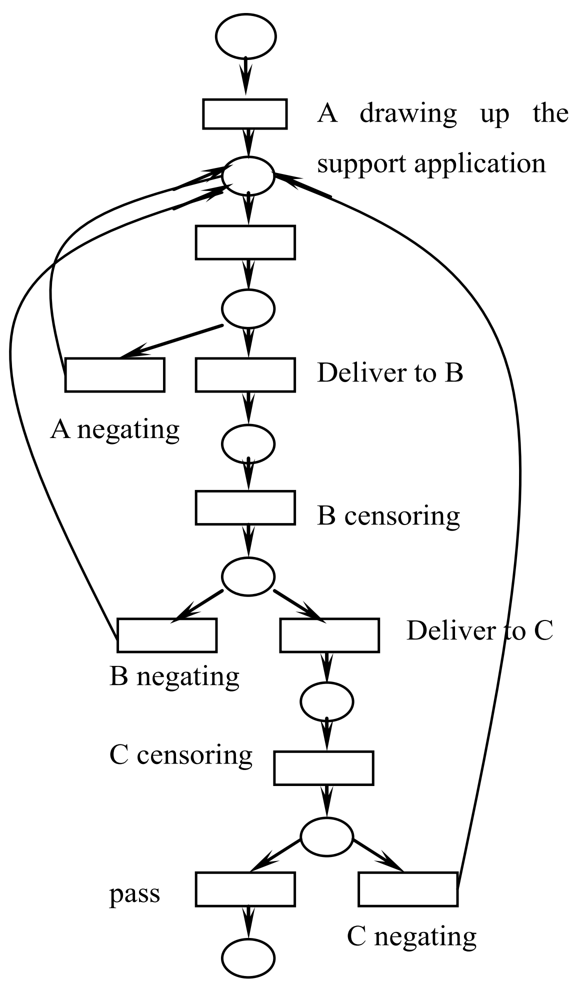

Figure 1. Workflow sequence model.

A. *Sequence model*

In the usual situation, according to the electric power monitoring category as well as the capital source, the difference in process flow of electric power monitoring is very big, The corresponding management flow becomes quite complex, that's the main reason we use Petri net to model.

In order to elaborate clearly, we only take a part of the electric power monitoring progress track management as the example to explain. In the process of electric power monitoring, when the A discover the turnover of capital or the dispatch of personnel has the question, it will write the application to submit for B. After B examines the application, then it will hand over to issue C, After the C examines the application, C will send out the opinion to A. According to the above, we established the workflow model like Figure 1. From the Figure 1, we may see this is a "sequence" model.

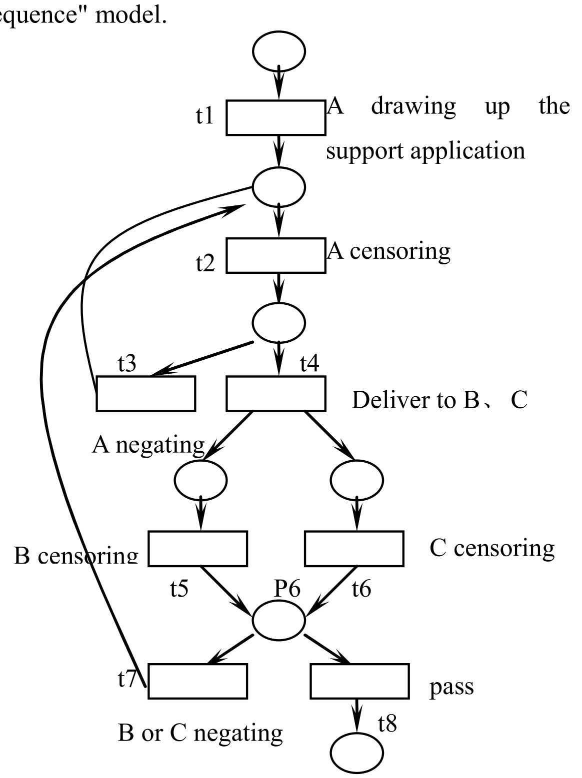

Figure 2. Concurrency model.

B. *Concurrency model*

As a reliable, secure, reusable electric power monitoring system, we should consider each kind of situation. For instance, in previous example, the electric power monitoring which some like electric power monitoring departments are intercurrent, A department may send out the application to issue B and C at the same time, both of them might send out the information to A discretionarily. Like Figure 2. Such B and C may open the application as necessary which needs to be verified, the model enhanced the working efficiency greatly. Meanwhile to the system designer, they realized "the flow to be born again". Certainly, at this kind of situation operator will choose concurrent transmission pattern.

C. *Collision model*

In concurrency model of Fig 2, there is collision. We cannot see synchromesh p6 ((t5, t6), (t7, t8), (2, 1)) belongs to which kind of mixed selection device. After translation t5 and t6 occur, does the choice carry out t7, carry out t8, or carry out t7 and t8 at one time? This needs to use the workflow semantic to dispel the collision. Like Figure 3 shows.

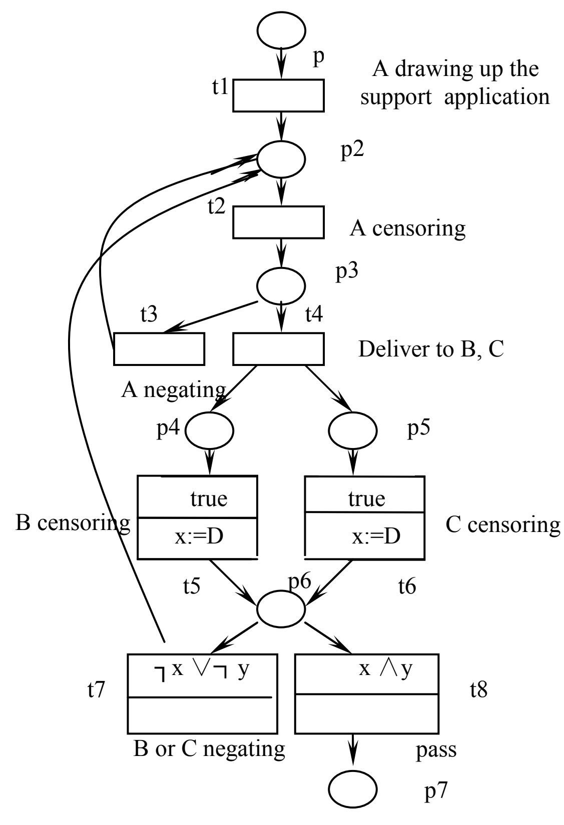

Figure 3. Collision model.

In the system, the verification will be carried on by two organizations B and C, we will use boolean variable x represent B pass the verification, boolean variable y represent C pass the verification respectively. We use $x \wedge y$ to express the support application verification to be passed, namely B and C both pass this support application verification. We use $\neg x \vee \neg y$ to portray verification is not be passed, namely B or C does not pass, then this application is not passed. Through defining variables, we may see this synchromesh belongs to syncretic selection, namely no matter what x and y is, only one electric power monitoring pot way may be chosen, it not only solved the collision, moreover has guaranteed the throughness of the model.

V. VALIDATING THE CORRECTNESS OF MODEL AND APPLYING IN THE DEVELOPMENT

If a workflow model satisfies throughness, well-structured and free-choice, then this model pass the accurate confirmation [5]. We will check the correctness of the collision model in Figure 3.

Analyzing the collision model, it satisfies the formalized definition:

∑=（P,V,T;F,K,W,R,Wr,MT,M0）:

P={p1,p2,p3,p4,p5,p6,p7};

V={x,y};

T={t1,t2,t3,t4,t5,t6,t7,t8};

F={(p1,t1), (t1,p2), (p2,t2), (t2,p3), (p3,t3), (p3,t4), (t4,p4), (t4,p5), (p4,t5), (p5,t6), (t5,p6), (t6,p6), (p6,t7), (p6,t8), (t8,p7),

(t3,p2), (t7,p2)};

K(p3)=K(p6)=2, K(p1)=K(p2)=K(p4)=K(p5)=K(p7)=1;

W(p3,t4)=W(p6,t7)=W(p6,t8)=2,others are 1;

R={(x,t5),(y,t6)};

Wr={(y,t5),(y,t6)};

MT as follows:

Ff(t5)=<p4,t5>, Fb(t5)=<t5,p6>,

Ff(t6)=<p4,t6>, Fb(t6)=<t6,p6>,

Ff(t7)=<p6,t7>, Fb(t7)=<t7,p2>,

Ff(t8)=<p6,t8>, Fb(t8)=<t8,p2>;

E(t5)=E(t6)=true,

E(t7)= ┐x □┐y,

E(t8)= x □y;

body(t5)=body(t6)≡y:=D,

body(t7)=body(t8)=null;

Throughness refers to any token in the source place can arrive the end place finally in the model, and is nothing with the dispelling method. Namely any form can be processed successfully in the model. From the definition of [1], we may know, if a model can be simplified to only one place, then the model satisfies throughness. To the collision model in Figure 3, firstly we can eliminate the translation t5 and t6 by using the simplification rule 14-6 in [1], then again the other translations by using the simplification rule 14-3, finally the model is simplified to one place, therefore the model is throughness.

Well-structured refers to the source place and end place in the workflow model are connected by a translation t * to obtain a strong connection model, in the strong connection model, it's parataxis synchromesh and selection synchromesh appear in pairs. According to the examination rule of [1], this collision model satisfies:

1) *for ti, i□(1-7),|.ti|=1;*
2) *for ti and tj, i,j□(1-7),|ti. .tj|=1;*
3) *In this model, there is only t4. .t6={P5},t4. .t5= {P4}:* But P4 and P5 do not belong to the same selector. so the model satisfies well-structured too.

Free-choice refers to for any two translations which contain the same input, their input set should be equal. In this model, it can be seen directly, therefore the model satisfies free-choice too.

According to above, we can determine the collision model passed the accurate examination. Moreover, the whole workflow models of the system have also passed the accurate examination.

In the practical development of the electric power monitoring system, for each item we can design a symbol word which contains more than one attributes to correspond to each flow and its state, set multilevel powers to insure different power supervises and controls different workflow.

VI. CONCLUSION

This paper introduced the Petri net method and workflow technique in brief, made use of workflow to model in the electric power monitoring system, optimized the design process, We successfully settled the concurrency and collision problems encountered in the design flow by using workflow network as the analysis tools to system. It is greatly significant for us to design the systems with complex workflow.

In the future studies, we will model the various workflows in the electric power monitoring system, and will further verify the solution about concurrent and conflict model in the developing of the electric power monitoring system.

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