Management System Process Modeling Based on Petri Nets and WF-Net

Yunpeng Cai
Modern Equipment Laboratory
Shenyang Institute of Automation, Chinese Academy of Sciences; Shenyang Normal University
Shenyang, P.R.China

***Abstract*—the process modeling is very important in the design of software system based on technology of workflow. This paper discuss the application of process modeling in the design on MIS, introduce the theory of WF-Net and the way of process modeling using WF-Net as the tool of modeling ,bring forward a new mapping method from the business model to the WF-Net model. An example of a process modeling based on WF-Net which from the design of the sale management information system is given.**

Keywords- Petri nets; WF-Net; Workflow; Process modeling

I. INTRODUCTION

The Workflow Management Coalition (WfMC) defines workflow and workflow management system as follows: workflow 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; workflow management systems one which provides procedural automation of a business process by management of the sequence of work activities and the invocation of appropriate human and/or IT resources associated with the various activity steps[1,6].

Because the objective is to support the execution of individual tasks, the traditional system design method is only suitable for such situation: the system scale is small or medium and the business process rule is relatively stable. However, in the large and complex system, to control, monitor and support the business process is more important than to execute the individual tasks using information system. In the other hand, with the continually development of business, changes or modifications to data resources, operation sequences, and business rule continually arise. For example, In petrochemical company integration management system, our recently project, business process consists of plan, sale, transportation schedule, workshop, financial, and after sale. More complex business process than general commercial process need information system provide corporation feature in several tasks.

These large and complex systems must be designed as workflow management system. We need the mapping method from the business model to the WF model.

II. PROCESS MODELING IN WORKFLOW MANAGEMENT

At the highest level, all workflow management systems may be characterized as providing support in three functional areas: the Build-time functions, he Run-time control functions, and the Run-time interactions. The Build-time functions concerned with defining, and possibly modeling, the workflow process and its constituent activities [1, 5].

The Build-time functions are those which result in a computerized definition of a business process. During this phase, a business process is translated from the real world into a formal, computer processable definition by the use of one or more analysis, modeling and system definition techniques. The resulting definition is sometimes called a process model, a process template, process metadata, or a process definition. For purposes of this document, the term 'process modeling' will be used [1].

Among the several methods, WF-Net is very powerful for modeling workflow management system.

III. WF-NET

A. *Definition of WF-Net[2,4]*

Definition 1 (Petri net): A Petri net is a triple (P, T, F)

P is a finite set of places,

T is a finite set of transitions ($P \cap T = \phi$);

$F \subseteq (P \times T) \cup (T \times P)$ is a set of arcs (flow relation)

A place p is called an input place of a transition iff there exists a directed arc from p to t. Place p is called an output place of transition iff there exists a directed arc from t to p.

Definition 2 (WF-net): A Petri net PN = (P; T; F) is a WF-net (Workflow net) if and only if:

1) PN has two special places: i and o. Place i is a source place: $\bullet i = \phi$; Place o is a sink place: $o \bullet = \phi$.

2) If we add a transition t* to PN which connects place o with i (i.e. $\bullet t = \{o\}$, $t \bullet = \{i\}$), then the resulting Petri net is strongly connected.

Places in the set P correspond to conditions; transitions in the set T correspond to tasks. Tokens in a WF-net represent the workflow state of a single case. The workflow state contains partial information about the state of a case. In addition the case has workflow attributes and application data. The workflow state corresponds to the distribution of tokens over the places (marking) [2].

978-1-4244-6498-2/10/$26.00 ©2010 IEEE

B. Routing constructs

In the process dimension, building blocks such as the AND-split, AND-join, OR-split and OR-join are used to model sequential, conditional, parallel, and iterative routing. Clearly, a WF-net can be used to specify the routing of cases.

- **Sequential routing**

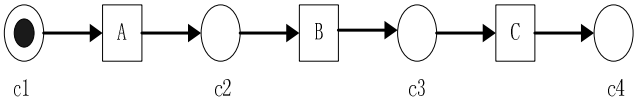

Figure 1:sequential routing

Sequential routing is used to deal with causal relationships between tasks. Consider two tasks A and B. If task B is executed after the completion of task A, then A and B are executed sequentially. Figure 1 shows that sequential routing can be modeled by adding places. Place c2 models the causal relationship between task A and task B, i.e., place c2 represents a postcondition for task A and a precondition for task B. Place c3 models the causal relationship between task B and task C [3].

- **Parallel routing**

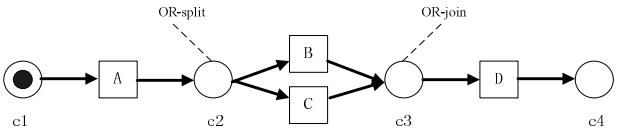

Figure 3:Conditional routing

Parallel routing is used in situations where the order of execution is less strict. For example, two tasks B and C need to be executed but the order of execution is arbitrary. To model such a parallel routing, two building blocks are used: (1) the AND-split and (2) the AND-join [3].

- **Conditional routing**

Conditional routing is used to allow for a routing which may vary between cases. In this way, the routing of a case may depend on the workflow attributes of a case, the behavior of the environment, or the workload of the organization. To model a choice between two of more alternatives, two building blocks are used: (1) the OR-split and (2) the OR-join (in both cases an exclusive OR).

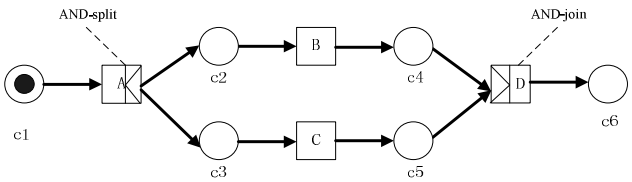

Figure 2:Parallel routing

shows the situation where task A is followed by either task B or task C, i.e., a choice is made between B and C. The execution of one of these two tasks is followed by the execution of task D. Place c2 is a precondition for both B and C. However, just one of these two tasks will be executed for the case in place c1.

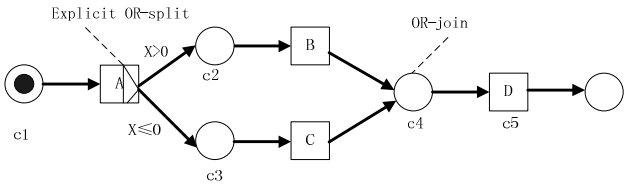

Figure 4:Explicit choice

c2 Transition A has two output places c2 and c3. Transition A produces either a token in c2 or c3. The choice between c2 or c3 is based on workflow attribute x.If x is positive, task B will be executed, otherwise task C. A special symbol is used to denote the fact that task A is an OR-split (exclusive OR)[3].

- **Iteration routing**

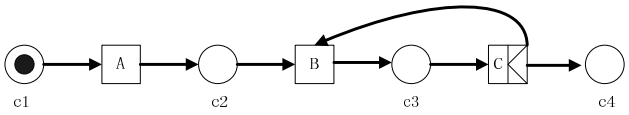

Figure 5:Iteration

Task C is a control task which checks the result of task B. Based on this check, task B may be executed once more. task B is executed one or more times. It is also possible to specify that task B is executed zero or more times [3].

C. Triggering

A trigger is an external condition which leads to the execution of an enabled task. The execution of a task instance for a specific case starts the moment the task instance is triggered. A task instance can only be triggered if the

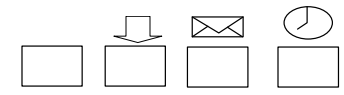

Figure 6:Four types of triggering

corresponding case is in a state which enables the execution of the task. We distinguish between four types of tasks.[2]

Automatic: a task is triggered the moment it is enabled.

User: a task is triggered by a human participant, i.e., a user selects an enabled task instance to be executed.

Message: an external event (i.e. message) triggers an enabled task instance.

Time: an enabled task instance is triggered by a clock, i.e., the task is executed at a predefined time.[3]

D. IMPROVEMENT OF WF-NET

Although WF-Net meets the most requirements of process modeling, it should be noted that, because of its theoretical basis of Petri nets, it also exist some of the problems.

First of all, Petri nets cannot solve the problem with the timing calculation requirements. Although WF-Net has time trigger mechanism, but not give the definition of transition's time delay and trigger time interval. We need to modify the

original system, add new process elements to achieve new time management features.

We extend the WF-Net to include business processes time factor, and map from activities (process) execution time to transitions (process) and the survival time to model time sequence dependency constraint between tasks, include the start and end time, delay time, survival times, the minimum and maximum delay time from enabled to trigger .

Second, Petri net is a model oriented control; enable the transitions by tokens flowing between places. The problem is token has not recording capability, but in practical application the enable or trigger to transition is determined by information content. Based on this need, token should have the additional capability to record and change process data.

We add a extended data attributes D to Place to bring the necessary data information needed by transition. At the same time we add a extended attributes C to Transition, to indicate the predicates and function associated with transition. D is the data collection including data or database table. C is transition control rules collection, including transition starting conditions, ending conditions, the operation sets and the control rule sets.

IV. IMPLEMENT OF PROCESS MODELING

A petrochemical company integration management system includes the sales plan, transportation scheduling, financial and after sale subsystems. Complete a sales process needs to consider production status, Inventory, sale plans, customer loan balances, rail transportation plan, cargo handling productivity and other factors involved in marketing planning, transportation scheduling, plant, financial, technical services, workshops and other departments, and all departments must work closely together to ensure a coordinated sales activities smoothly.

We use the improved WF-Net technology and the above workflow components and the trigger mechanism on this system process modeling, the model is bounded, activity and complete. Existing business processes the necessary adjustments to eliminate the system of factors likely to cause system deadlock. Part of the model is shown in Figure 7.

On Figure 7 as follows: the tokens in the initial place are representative of a new marketing plan started. Sale Department receives a monthly sales plan from Planning Department, which is a time-triggered activity can be completed by the system. Then based on customer purchase intentions (message triggered activity) apply rail transportation plan and receive approval from railway station (both user triggered activity). Transportation plan effective only one month, the monthly auto-trigger transportation plan expired at the end of activities, statistics transport data, and to save the file (all automation activities). To execute transport plan, train usage application and cargo application parallel begin. Transport department, after receiving transportation plan approval, apply the train usage application (message triggered). The approved train usage application processing is an explicit or branches: the self-train, to inform workshop to prepare loading; the other trains waiting for trains to arrive.

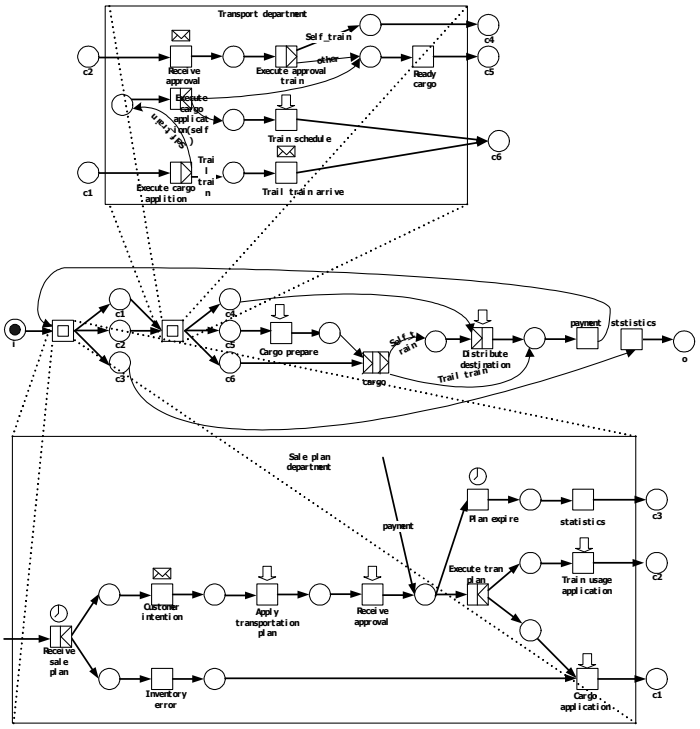

Figure 7: WF-Net workflow model

V. CONCLUSION

This paper discusses the WF-Net in the system process modeling, extends the classic WF-Net, adds data and time attributes to the net model, bring forward a new method mapping from business model to WF-Net model. The further study is object Petri nets (OPN) and the object Petri net language (LOOPN) modeling of complex systems.

Acknowledgment

The research described in this paper was partly supported by the National Natural Science Foundation of China (Grant No.79931000).

REFERENCES

[1] Workflow Management Coalition. "The Workflow Reference Model.WFMC",TC00-1003.http://www.wfmc.org/Downloaddocument/TC00-1003-The-Workflow-Reference-Model.html, 1995 , p. 6

[2] Van der Aalst W M P.Structural characterizations of sound workflow nets. Technical Reports, 96/23, Eindhoven: Eindhoven University of Technology,.http://citeseer.nj.nec.com/vanderaalst96structural.html,1996,pp.15-35

[3] Van der Aalst W M P.The Application of Petri Nets to Workflow Management [J]. The Journal of Circuits, Systems and Computers, 1998.8(1):15-23

[4] Yuan Congyi, Petri Net Theory[M].Bejing:phei,1998,pp.51-75

[5] Fan Yusun, Workflow management technology foundation, Bejing:TUP,2001,pp.60-90

[6] Luo haibin, Fan yusun, Wu chen, Overview of Workflow Technology, Journal of Software,2000.11(7),pp.899-907