Research on Mapping Petri-Net to UML in System Modeling

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Abstract. The paper analyzes the need of complex system modeling. According to the advantage and shortage of UML and Petri net, comprehensive usage of Petri net and UML can efficiently improve the comprehensiveness, consistency, accuracy and completeness of the model describing. The translation rules from Petri net model to UML model were proposed. So the object model can be analyzed and verified better.

Introduction

A model is the complete abstraction of a system, and the model including the comprehension and understanding that how to solve the problem and the solution of the problem. The model makes up of element and has certain system structure. The system model is the abstraction of actual system. For the huge system which has many equipments and complicated conjunction relation, how to optimize the information interaction is emphases. It has high request for the real-time communication and the cooperativity of the sub-system. The information interaction relation and type that between the system and sub-system and inner sub-system is complicated. And it has high request for real-time. Making good model for this kind of system, it can build up good foundation for development and maintenance of system.

Petri Net

Petri net is put forward by Germany Carl Adam in his doctor dissertation in 1962 firstly. Petri net can not only be used to analyze the static structure, but also the dynamic behavior. And it is a kind of mathematic and graphical tool to describe and analyze. To develop the information processing system which is parallel or asynchronous or distributed or concurrent or indeterminacy, it can construct the Petri net model and analyze. Then, we can get the information about the system structure and the dynamic state behavior. According to the information, we can evaluate and improve the system.

The state element and variety element of Petri net use Place and Transition to express respectively. The function of transition is changing the state, and the function of place is to decide whether the transition can take place. The dependency relationship between transition and place uses directional-arc (arrowhead) to denote and it is a Petri net. We use circle to represent the place, and use rectangle to represent the transition, and use directional-arc to represent the input that from place to transition and output that from transition to place. During building the model, if use the concept of condition and events, then position represent the condition and transition represent the events, and all these can constitute a Petri net, such as Fig. 1.

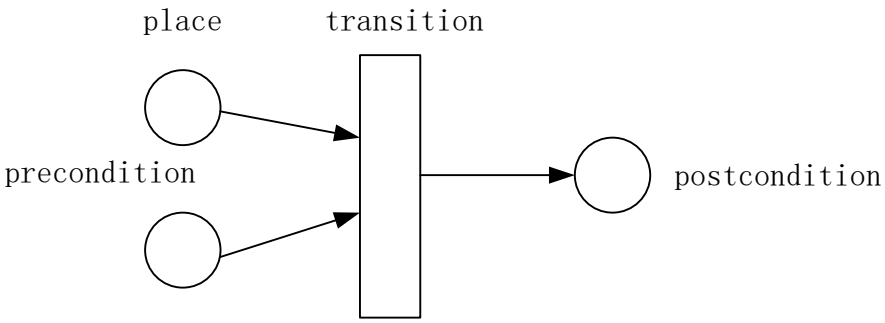

Figure 1. Petri net

Fig. 1 shows that the events are the action taking place in the system. The occurrence of these actions is controlled by the state of system, while these states can be described with a set of condition. Condition is the property or logic description of system and a condition can be established or not established. Because the event is an action, it probably takes place. The occurrence of an event may need a few conditions to be established at the same time, and all these conditions are called the prior condition of event. The occurrence of the event may cause the prior condition disappear and produce other conditions, and those conditions are called subsequent condition. Petri net studies the structure and dynamic behavior of system, and pay attention to the state variety and the relation of variety that possibly take place in the system. The Petri net can describe the dynamic character of system laconically, such as concurrent, conflict synchronous etc. It has corresponding analysis method. So Petri net is broadly applied in buildings model and analysis.

The introduction of UML

Along with the advance of system's complicacy, it is more and more urgent to the need of good model language. UML develops with the object-oriented system analysis and design. It is mainly used to build the system model within the analysis and design stage, and it has scalability and commonality. Being the third generation object-oriented modeling language, it is a kind of graphical language, including demand analysis and structure and allocation.

The definition of UML includes semanteme and notation. The semantic description is based on the definition of accurate metamodel. The metamodel provides a brief and consistent and general definition elucidation for the elements in semanteme and notation. With these, developer can obtain unanimity on semanteme.

UML includes use case diagram and collaboration diagram and interaction diagram and sequence diagram, and can also induce for the static state modeling mechanism and dynamic modeling mechanism. Fig. 2 is the step of UML modeling process.

Being an object-oriented model tool which has good definition and easy expression and direct description, UML provides effective tool for design and analysis of information system. But while constructing complicated and huge system, it is difficult to embody the crytic concurrency between objects and the consistency of constraint rule between objects. And it is also difficult to display the dynamic behavior character completely.

UML is applicable to describe any type of system with object-oriented technique, and is applicable to different stage of system development. From the need description to the test and maintenance after completing, UML all can be used.

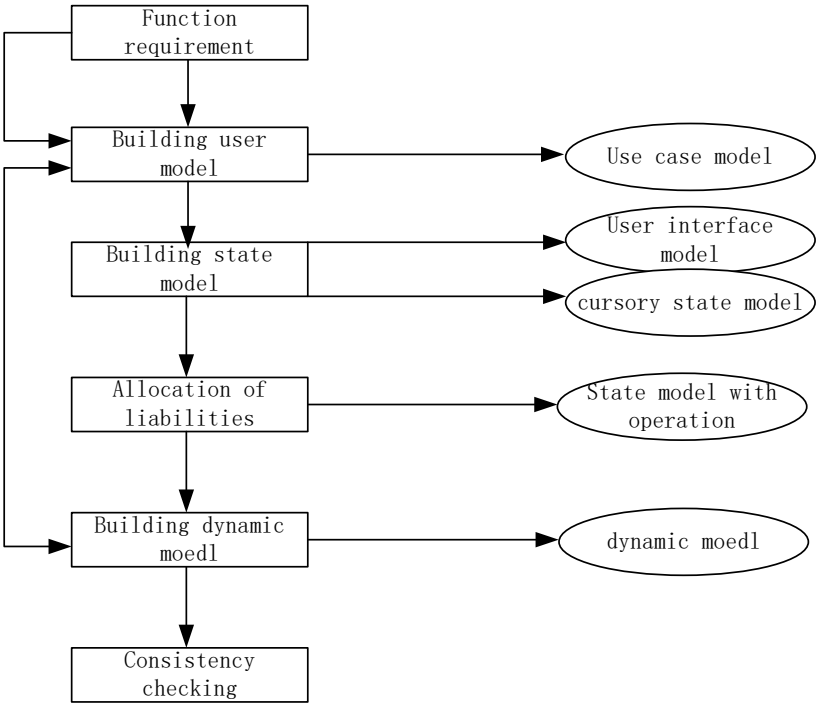

Figure 2. UML modeling process

According to the different peculiarity of UML and Petri net, we can combine UML with Petri net, bringing out the best in each other. Firstly, we make use of UML's chart element to describe model and design the object in the system. Then, according to the complexity of model, mapping a part of UML model which is necessary to Petri net model based on certain rule. And then, carry on analysis and optimization. The result can amend the UML model. At last, convert those models into UML statechart and sequence diagram, and constitute an integrity UML model with other charts, such as Fig. 3.

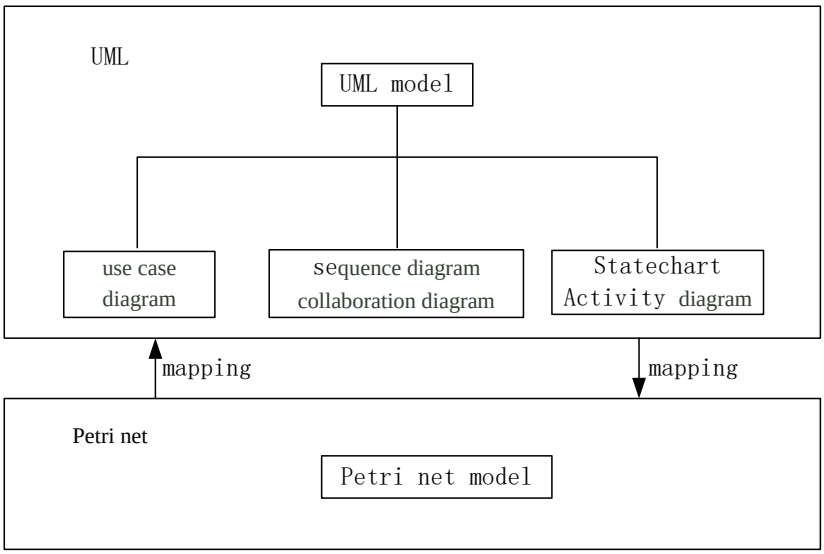

Figure 3. Model frame

Petri net model mapping to UML model

According to Fig. 3, it can abstract the mapping process from Petri net model to UML model, such as Fig. 4. The mapping rule is as follows:

The place in Petri net model mapping to properties of objects in UML model。

The Subnet in Petri net model mapping to statechart of object in UML model. The place corresponds to the activity in statechart and the transition corresponds to the action in the statechart.

The transition in Petri net model mapping to activity in UML activity diagram, and the place mapping to condition.

The door transition in Petri net model mapping to the message event in UML interaction diagram (sequence diagram and collaboration diagram).

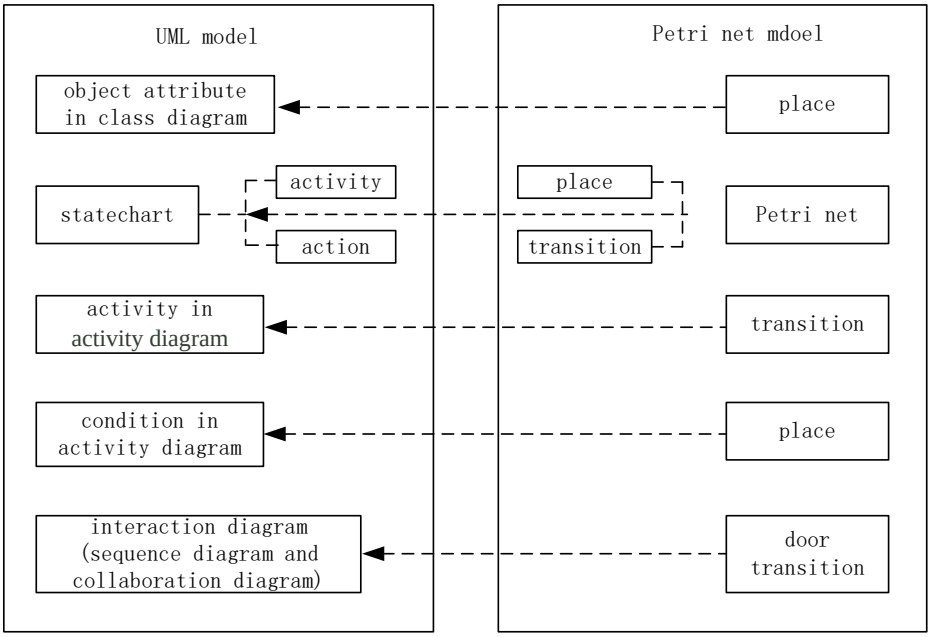

Figure 4. Petri net model mapping to UML model

During the model process of complicated system, it can use various tool of Petri net to analyze and optimize the model. In order to get a unify view and create code expediently, converts it to UML model and constitute a unifying UML system model. The Petri net model can describe the concurrent and conflicts and synchronization between different objects. After converting to sequence diagram, it can embody the concurrent and conflicts and synchronization. According to the reflecting rule of Fig. 4, reversing thinking, Sub Petri net converts to object's state chart, and the place converts to activity of state chart, and the transition converts to action of state chart, etc.

It can get conversion rule: state position responses to the state of UML model, and the message position responses to the event, and the transition responses to the event, and arc responses to conversion. Using the above rule, establish the mapping such as Fig. 5.

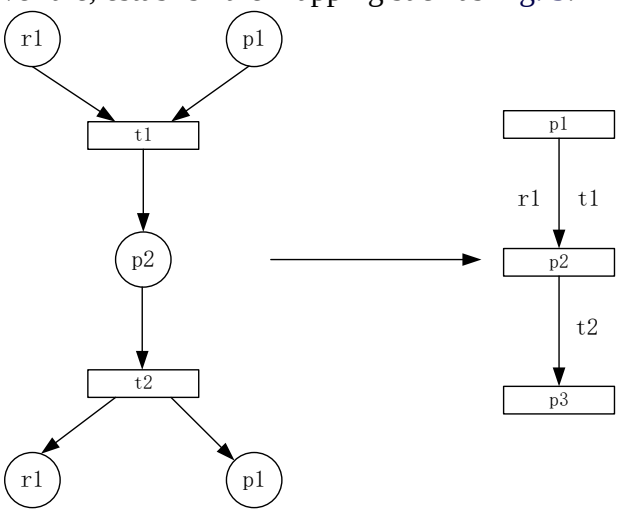

Figure 5. Petri net mapping to State chart

In the figure, r_1 express resource place, and t_1、t_2 express transition, and p_1、p_2、p_3 express state place.

The conflict Petri net mapping to sequence diagram as Fig. 6, and use the solid lines with the hollow circle at both ends to connect the conflict set, and all the message in the conflict set is thought to be mutual conflict, and each time has only one message take place.

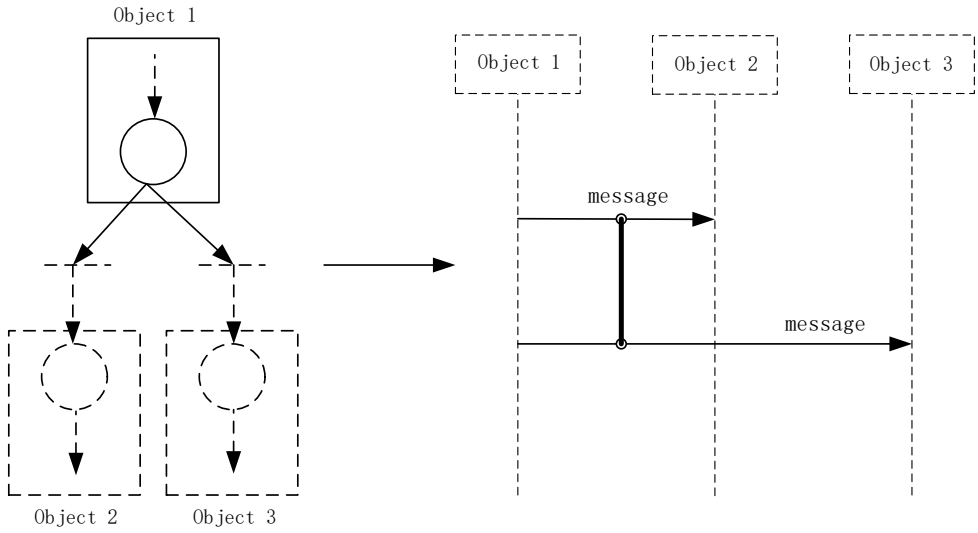

Figure 6. conflict Petri net mapping to sequence diagram

The concurrent Petri net mapping to sequence diagram as Fig. 7, and use the solid lines with the solid circle at both ends to connect the concurrent set, and all the message in the concurrent set is thought to be concurrent, and those can take place at the same time and do not influence each other when the condition satisfy.

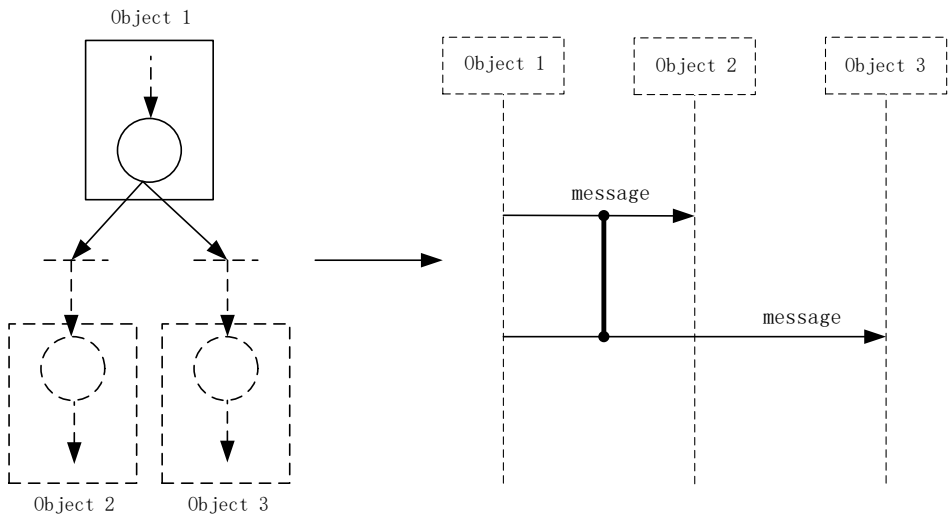

Figure 7. Concurrent Petri net mapping to sequence diagram

The synchronization Petri net mapping to sequence diagram as Fig. 8, and use the solid lines with the hollow diamond at both ends to connect the synchronization set, and it can trigger the nest event only when all the message in the synchronization set is carried out thought to be concurrent.

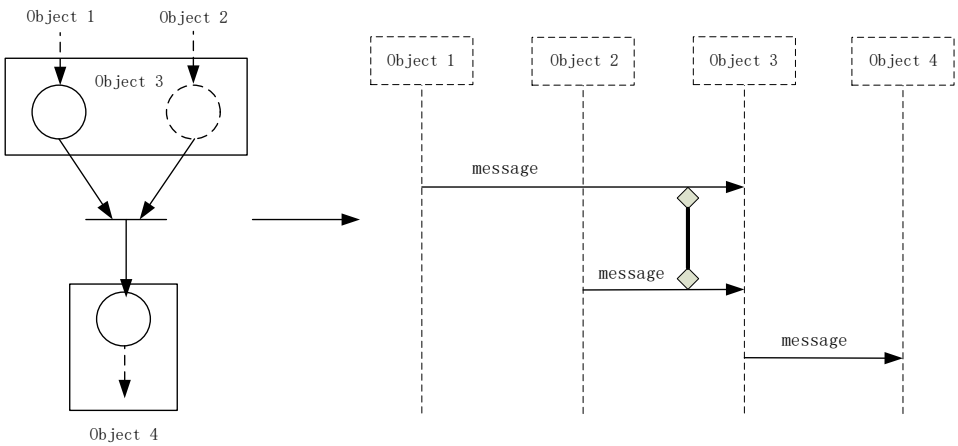

Figure 8. Synchronization Petri net mapping to sequence diagram

Using the above mapping rule to convert the Petri net model to UML model, finally it integrates all UML models. Combining Petri net and UML model, it shows the advantages of both methods. It mapping a certain necessary UML model to Petri net model based on mapping rule, and carry on analysis and optimization and mathematical description. Then convert to unify UML model based on mapping rule. It becomes a kind of perfect modeling method and can raise the efficiency.

Acknowledgements

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