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DESIGN AND MODELING OF ONE FEASIBLE ELEVATOR CONTROL SYSTEM BASED ON PETRI NETS

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ABSTRACT

In this paper, elevator control and traffic planning system are designed and simulated under Petri Net-based principle. Without a doubt, the elevator is one of the most important facilities in modern urban life. As higher the building has been built, the more essential the elevator becomes; the troubles caused by the control system might lead to irreversible accidents; therefore, it is a significant issue to design the control system and traffic planning with safety concern. We proposed the control theory and traffic planning for both single and multiple elevators; it is also proved by stimulation that the method we present is superior to the published paper.

KEYWORDS: Elevator, Petri Net, human–machine interaction, dynamics discrete event system, traffic planning.

1. INTRODUCTION

With the development of technologies and medical treatment, the death rate of human beings is dropping dramatically. However, the area of land will not increase with the population. The deficiency of land raises the population density and urges people to increase the land utilization rate. Hence, more and more mansions and skyscrapers are built. Accordingly, the elevator is invented to move vertically inside.

To adapt to a special site or fit specific needs, the elevator can be magnified for many functions. For instance, the elevator in the department stores is set to extend the opening time to wait for customers. The elevator in the hospital is equipped with an emergency device in case of any critical patients. Some hotels design the elevator to stop at the specific floor inconvenience for their clients. Those functions increase the experience and diversity of elevators. In a certain crowded place such as shopping mall and department store, it is usual to install more than one elevator to decrease the waiting time and transport people efficiently.

The invention of the elevator brings conscience, yet it may cause some troubles. For example, the door may jam people when closing, the emergency call when the elevator is malfunctioning, and the resource waste due to traffic planning. In this paper, we focus on researching the wasting of resources caused by non-perfect traffic planning.

In previous studies, there are many methods used to simulate and analyze the operating of the elevator, such as Time Petri Net[8, 9], Coloured Petri Net[4], Predicate Transition Petri Net, Statechart[3, 5, 7, 10] and Java, we utilize Petri net and simulate with Hpsim.

The rest of this paper is organized as follows. The second part demonstrates the principal and characteristic of Petri Net. The third part describes and discusses the design and simulation of the elevator. The fourth part will present the future development, and the fifth part is the conclusion.

2. Petri Nets

The theory of Petri Net is presented by Carl Adam Petri in 1962[4], it is a system construction tool with mathematics and graphical characteristics to simulate and analysis arbitrary system. With more and more related researches been studied, novel applications based on Petri Net has been developed, such as Time Petri Net, Coloured Petri Net, Predicate Transition Petri Net and so on.

Petri Net is composed of one class of Place (P) present by a circle, one class of Transition (T) present by a rectangle and multiple Arc (A) to connect Place and Transition. Each P class consists of a black dot, which is called Token.

According to the definition, every Token in the P class needs T class to be enabled, the Token will then be transmitted after being stimulated and cause the change of the status. The condition to enable T class is that every input place of the Transition should have one Token number. The qualified Transition will move one Token in the input place and create a Token in the output place. Hence, the transition of each Token and the stimulation of the Transition will change the status of every Place and vary the condition of the whole Petri Net, as shown in Fig. 2.

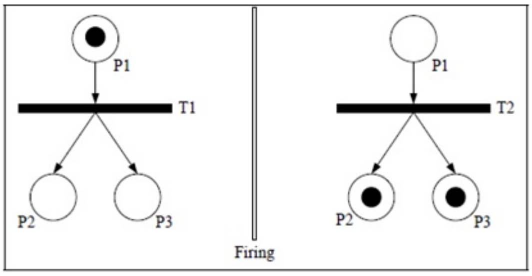

Fig. 2 The diagram of Stimulation.

In the beginning, the P_1 is consist of a Token, it satisfy all input place with a Token for T_1, so T_1 can be enabled and stimulated. The stimulated transition t_1 will then yield the Token to the output places of next Place, which are *P*2 and *P3*. This shows that the operation mechanism between Token and Transition will satisfy different condition that leads to different process and result. The traditional Petri Net includes the elements shown in Table 1.

Table 1. The definitions of Petri Net Elements.

Petri Nets Elements	Definitions
Place	The state, condition or storage space of resource
Transition	Transitions or events
Token	Resources or information
Arc	The direction of controlling, resource and information

3. The Proposed Models

3.1. Single- Elevator

In the single elevator design, there are external interfaces locate on each floor. When the users press the button, the system will determine the position and the distance between the elevator and where the users are. If the elevator is located above the user, the system will transmit a signal that move down the elevator; if the elevator is located under the users, the system will give a signal to move up the elevator to reach the users; however, if the elevator and the users are on the same floor, the elevator remain at the current position, and the Token in the human-machine interface will fire to c_1, as shown in figure 3 and table 2.

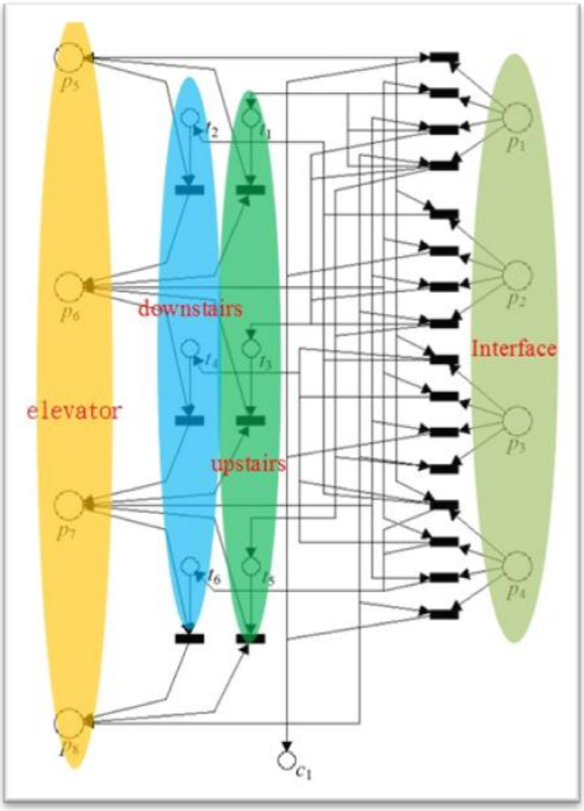

Fig. 3 The model of single elevator.

Table 2. Model of Single Elevator.

Object	Representation
p_1	4th floor (Interface)
p_2	3rd floor (Interface)
p_3	2nd floor (Interface)
p_4	1st floor (Interface)
p_5	4th floor (Current position)
p_6	3rd floor (Current position)
p_7	2nd floor (Current position)
p_8	1st floor (Current position)
t_1	upstairs (3→4)
t_2	downstairs (4→3)
t_3	upstairs (2→3)
t_4	downstairs (3→2)
t_5	upstairs (1→2)
t_6	downstairs (2→1)
c_1	Remained Token position

For instance, if the elevator is currently located in 4th floor, and the users call the elevator at the exterior of 1st floor, the situation is drawn as figure 4. After that, the human-machine interface will transmit a signal to the elevator which allows the elevator to determine the distance and position, as shown in figure 5. In the end, the elevator starts to descend to 3rd floor (Fig. 6), 2nd floor (Fig. 7) and 1st floor (Fig. 8) to finish the overall operation.

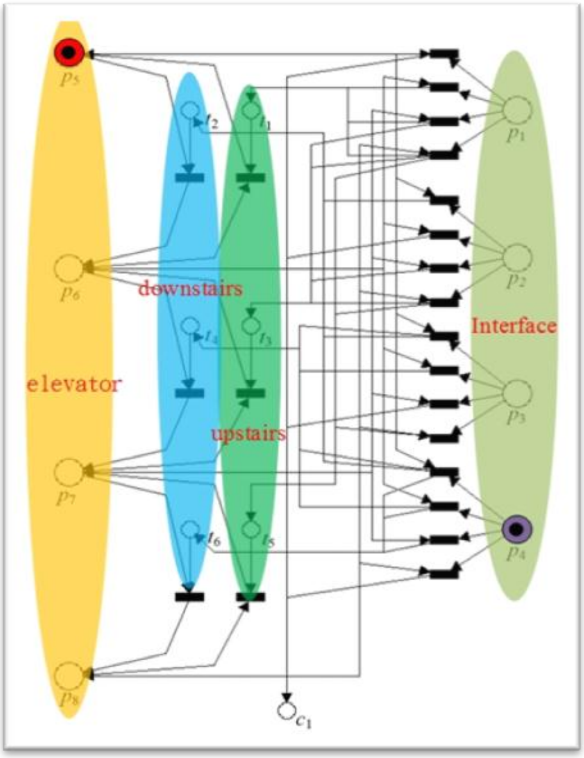

Fig. 4 Diagram of single elevator 1.

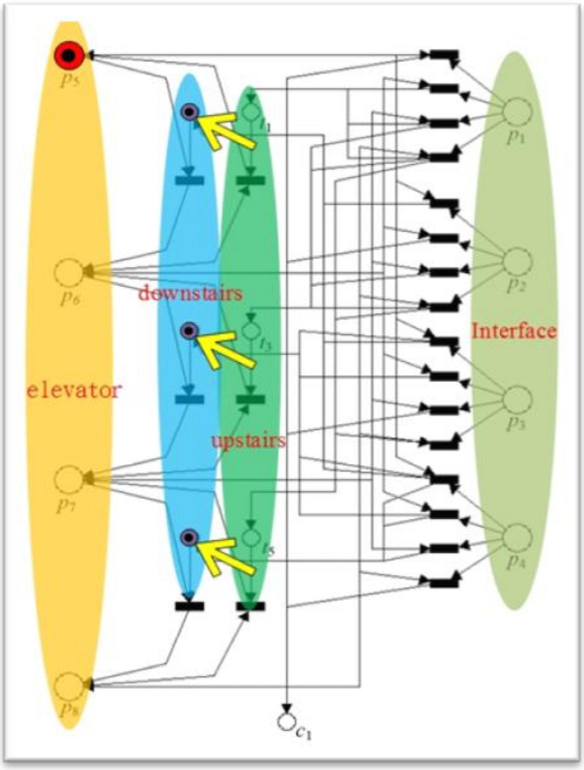

Fig. 5 Diagram of single elevator 2.

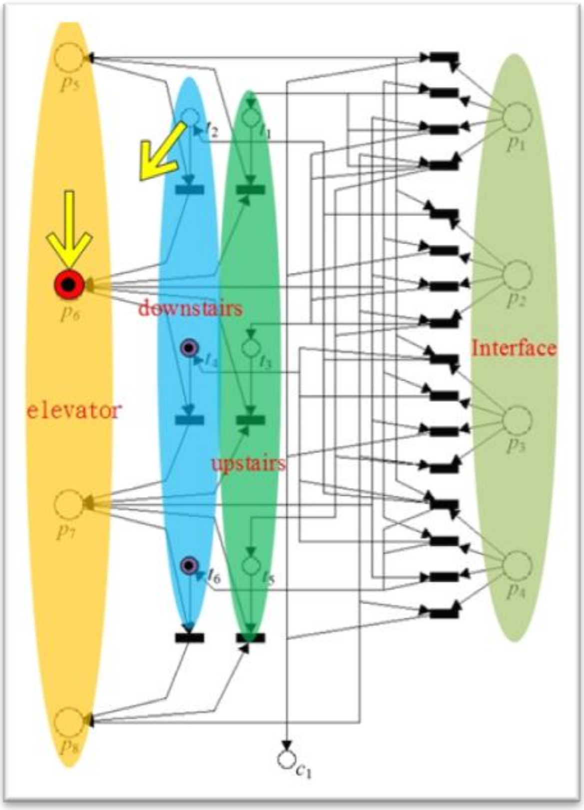

Fig. 6 Diagram of single elevator 3.

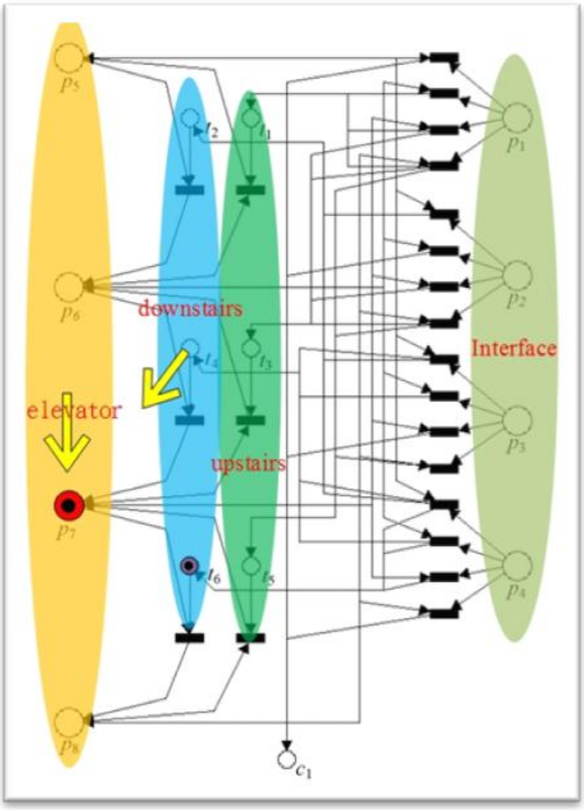

Fig.7 Diagram of single elevator 4.

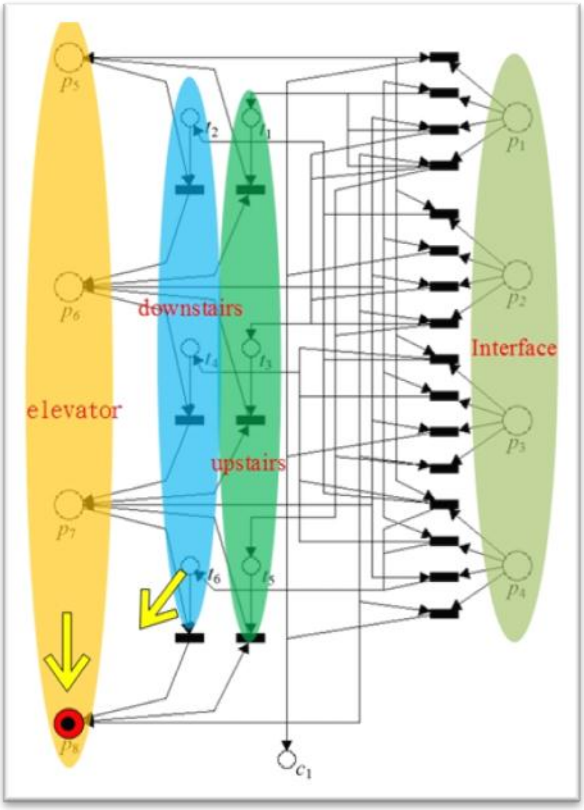

Fig. 8 Diagram of single elevator 5.

3.2. Multi-Elevator

The multi-elevator design is based on single-elevator, and we add an additional judgement to determine the nearest elevator toward the user. In this part, we demonstrate with two elevators. The principal is similar to that of the single-elevator, which contains one set of buttons on each floor. When the interface is used, three signals will be given first, which are the activation of elevator, activation of trafficking and the depletion of remained Token. When the elevator is activated, the signal are shown on each floor and the position of the elevator will be exposed. The trafficking will then be started, allow the system to determine the elevator closed to the user. For example, if the user located on 4th floor, the trafficking system will first decide whether there is elevator on that floor. If there's elevator on 4th floor, the elevator will be activated; if there's no elevator on 4th floor, the system will then continue the judgement and move the closest elevator toward the users. If both of the elevators stay on the same floor, the system will randomly activate one of it, the move the elevator toward the user and activate the Token depletion to remove the unused Token. The schemes are shown in Figure 9 and Table 3.

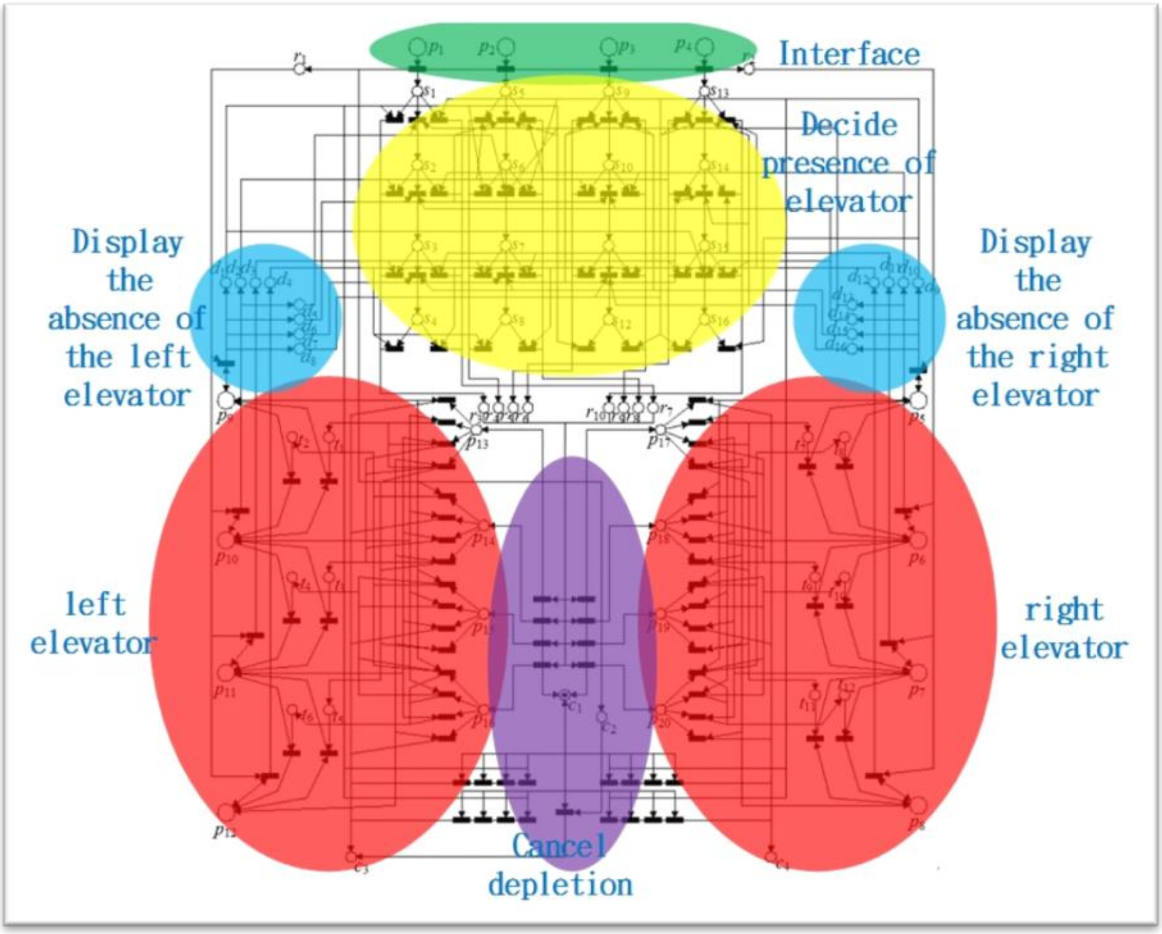

Fig. 9 Multi-elevator model.

4. Discussion and Future Work

The trafficking of electors is a complicated research topic. So far, this paper only presents the simulation of the human-machine interface of the exterior elevator and users' operation. Besides, the human-machine interface of the interior elevator[11], the postponed opening and closing of the elevator, emergency call, priority, sensory device, and overweight warning are the research issue in the future.

The future topic can be divided into short-term, intermediate-term and long-term goal. The short-term scheme is to study the operation when the number of user are more than two, and improve the design of elevator to extend the system that allow controlling from both internal and external of the elevators.

The intermediate-term goal is to permit controlling the elevator from both side of the elevators simultaneously. If there are users taking the elevators from 1st to 4th, and others are calling from the exterior in the 2nd floor at the same time, the elevator would stop at 2nd floor and wait for the users to finish controlling, and then keep operating, deciding whether to stop at the 3rd floor, and terminating the working after reaching 4th floor and showing the change of direction of the elevator. If the user tend to go downstairs as the elevator goes up, the elevator will first continue its direction until finishing the current command, and start to move conversely.

The ultimate goal is to add functions such as postponing the opening time, user's priority, and assignment of partial elevators to stop only at certain floors, improving the model step by step as it reach the modern elevator.

3. CONCLUSION

Elevator is one of the necessary amenities in our life. Without elevator, it is more difficult to vertical move inside a skyscraper. Because of its convenience, there are more and more people rely on it, a minor problem will then cause critical accident. To prevent the elevator from accident, we study the control system of the elevator to reduce possibility of failure and casualty and make it a safer facility.[16]

However, the control system of the elevator is much more complex than it seems to be. The more function it has, the more complexity it is. In this article, we utilize the basic Petri Net to simulate and successfully design a model for multi-elevator system. Compare to the group that also applied Petri Net to control and traffic[17], the process we presented in the paper can efficiently plan a time-saving route toward the users and move the elevator according to its mechanical principle instead of reaching in one step. This shows that the control theory is not only feasible but also superior to the existing method.

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Conflicts of Interest: The authors declare no conflict of interest.

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