Modeling China Metro Train Route Occlusion Operation Method Based on Time Petri Nets

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Abstract—*Urban metro signal system is a complex system to guarantee the safe and efficient running of urban metro vehicle, of which any equipment malfunction could induce danger. In the actual operation, the degraded mode of signal system is generally used to organize urban rail transit vehicle when the signal system work abnormally. The traditional degraded mode of urban rail transit signal system is telephone occlusion method, which cannot meet the demand of a large amount of passengers' evacuation for its low efficiency in organizing vehicles. In China, route occlusion, a novel degraded mode, is proposed by a few urban rail transit companies to improve the efficiency of transport in abnormal situation and further ensure rapid evacuation. This paper comparatively analyzes the capability of telephone occlusion and route occlusion to accommodate rail vehicles in an interval between two depots in the same scene. This paper, furthermore, models and analyzes telephone occlusion method and route occlusion method using Petri net in view of its unique advantage to describe asynchronous and concurrent system. Finally, an example of Chang Ping line of Beijing metro is particularized to explain the different efficiency to organize trains in degraded mode of urban rail transit signal system.*

Keywords-metro train, route occlusion, telephone occlusion, time petri nets

I. Comparison of Traffic Organization between Route Occlusion and Telephone Occlusion

A. Comparison of Ability to Accommodate Vehicles

Route occlusion and telephone occlusion is the basic alternative occlusion method. Telephone occlusion, whose certificate is the display of signal machine, is a method to confirm the outside interval idle, the station line free and subsequent get access to start into front station through two adjacent station attendants. Route occlusion method need to confirm whether the signal lamp is green or not only, without any telephone communication.

The schematic using route occlusion method and telephone occlusion method to organize trains is shown in figure 1.

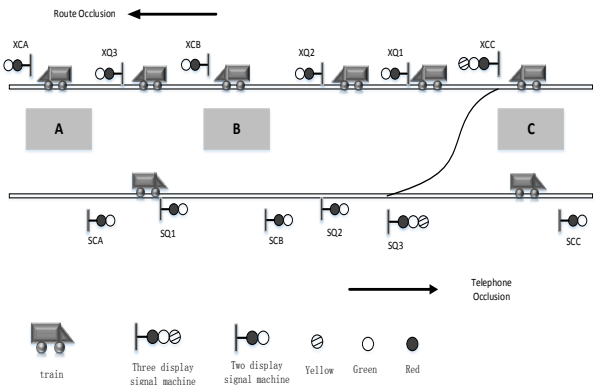

Figure 1 Schematic of route occlusion and telephone occlusion

SCA,SCB,SCC — Respectively represent the ascending signal machine to get out of the station of A,B and C.

SQ1,SQ2,SQ3—Respectively represent the protective signal machine of the demarcation

point of ascending interval.

XCA,XCB,XCC—Respectively represent the descending signal machine to get out of the station of A,B and C.

XQ1,XQ2,XQ3 — Respectively represent the protective signal machine of the demarcation point of descending interval.

Among which SQ3, XCC also play a role of protective signal machine before turnout.

In actual situation, the number of trains with route occlusion method is at least twice as much as telephone occlusion method. And if the number of protective signal machine between two adjacent stations is n (n>0), n+1 trains can be accommodated to travel in theory between the two adjacent stations. However, telephone occlusion method is only able to accommodate one train in any situation. Compared to the phone occlusion method, the advantage of route occlusion will be bigger and bigger along with the length of two adjacent stations.

B. Time Petri Net Modeling

We may get some conclusion from the above analysis that the number of trains that can be accommodated between two adjacent stations

with route occlusion method is more than telephone occlusion method. But it is essential for the difference of the number of trains passing through the same station within a certain time between route occlusion method and telephone occlusion method to establish a model of time petri net. The time petri net of route occlusion method and telephone method are as follows:

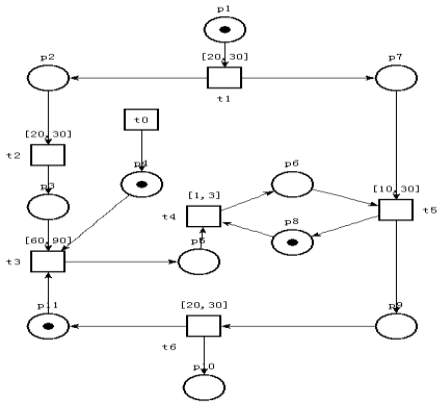

Figure 2 Time petri net of telephone occlusion method

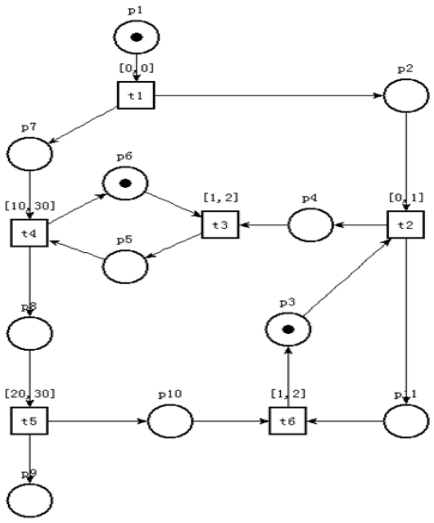

Figure 3 Time petri net of route occlusion method

Table 1 Definitions of some signs of telephone occlusion

place（P）	transition（t）
P1：The train is stopping and waiting for passengers to get on and off. P2：The anterior attendant received ask for starting train and getting access to the station. P3：The anterior station's line is free. P4：The receiving route is ready. P5：Mark of allowing train to access. P6：Symbol of opening signal. P7：The train is waiting for starting. P8：Symbol of closing signal. P9：Starting the train. P10：The train travel into main rail line. P11：The interval of two adjacent stations is idle.	t1: The attendant of rear station ask to anterior station for starting the train into the interval. t2: The attendant of anterior station check if the line is free. t3: The attendant of anterior station accomplished the check. t4: The attendant of rear station light the signal machine. t5: Closing the door and starting the train. t6: The train get out of the rear station.

Table 2 Definitions of some signs of route occlusion

place（P）	transition（t）
P1：The train is stopping and waiting for passengers to get on and off. P2：Section idle. P3：Line idle. P4：The sign of route locking. P5：The sign of route open. P6：The sign of signal closing. P7：The train wait to start. P8：Starting the train. P9：The train travel into the first interval of line. P10：The symbol of the train has started； P11：A line seizure.	t1: The system automatically check interval occlusion. t2: Locking approach. t3: Open the signal machine. t4: Start the vehicle and enter the route. t5: Close the door and start the vehicle. t6: Unlock the approach.

V. Conclusion

This article analyzed the different features between the two degraded mode of urban rail transit signal system, telephone occlusion method and route occlusion method, discovering that the route occlusion is able to accommodate more trains in one section of two adjacent stations than telephone occlusion method through simulating and depicting the different mode to organize trains. The protective signal machine is constrained by the curve line and climatic, which may conduct accidents that the train operators drive into protective area unexpectedly. Therefore, the position of prospective signal machine should be placed reasonably, for instance, increasing the repeating signal.

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