Modeling of Complex Apron Conflict Control Based on Petri Net Model

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Abstract—This paper uses discrete events modeling to apron surface activity control problem. Through dispersing runway taxiway and apron, discrete element map to Petri net basic element, build surface activity model based on Petri net. The paper build model of apron activity by Petri net theory, use Cptools simulate real apron activity, analysis and assess real activity efficiency of aircraft, prove validity of model and improve apron efficiency.

Keyword—petri net model; cptools

I. INTRODUCTION

Petri net theory research organization structure and dynamic activity of system, eyes on every kind of possible changes and relation between the changes. Petri net can describe system structure well, show parallel synchronization conflict and so on, simulate discrete events system briefly and directly by net diagram, it is suited to describe system organization structure and system condition changing. Petri net is developed, have a kinds of net system, such as condition/event net, place/transition net. These nets benefit for modeling of complex system. Petri net applys to design computer science.

This paper firstly discrete surface activity such as apron and apron axiway based on safety, models and simulates surface activities in an extended period, calculate and compares the activities, proves that controller model according to Petri net theory and applicability of rule.

II. MODELING

A. Linear Inequality Based on Petri Net

As for discrete event system, we need control the activities so that conform to special rules, the major rules divided into 5 types: ①resource conflict; ②deadlock; ③order norm; ④buffer overflow; ⑤operation rule; All of states about controlling in system space can map to allow and forbid. And in Petri net model, many controlling problems can transform into net system that conform to limit of a linear inequality. So we can make requirement of system into controlling problems of limit of a linear inequality.

linear inequality:

\[ l \cdot m \leq b \]  \hspace{1cm} (1)

In the equation, \( l \) means \( n \) dimensional place weighting vector quantity, every one of weighting vector is integer, parameter \( b \) means threshold value of sum of weighting vector.

Controlling goal make system meet the demands of a linear inequality, every one linear inequality can be:

\[ \sum_{j=1}^{n} l_m(p_j) \leq b \]  \hspace{1cm} (2)

B. Apron Using Rule

1) Rule of controlling 1

Based on safety of apron, only allow one aircraft push-back or push-in.

\[ m(cross) + m(park) \leq 1 \]  \hspace{1cm} (3)

2) Rule of controlling 2

Aircraft run from taxiway to apron, or from apron to taxiway, must enter the PB position, if position is not empty, wait here.

\[ m(pb) = 1, \text{full} ; m(pb) = 0, \text{empty}. \]  \hspace{1cm} (4)

III. AIRPORT GATE MODEL

Discretize apron sector as the FIGURE 1, set a apron with a push-back, build the relate model. Build model for aircraft in or out. The p1_out and p1_in means number 1 push-back and push-in, controller c_1 make only one aircraft in or out, p1_limit means gate position indicate controller. Then build the model by cptools as FIGURE 2.

![FIGURE 1. DISCRETIZE APRON SECTOR](image-url)
With the same way, build activities model of push waiting and taxiway in and out. Place CROSS and CROSS_1 means direction of taxiway to apron, place pb and pb_1 means direction of push waiting position to apron, c1 means make only one aircraft run, so, get the following FIGURE 3.

Apron taxiway possibly have conflict of center, so need controller c_12 and c_34 make exclusiveness of center resource, build the model as FIGURE 4.

These are major function model. Through these controller model and apron activities model, simulates real apron aircraft activities, assess the efficiency of aircraft in these models.

IV. EXPERIMENT CALCULATION

Function fun Trantime_line is used for calculating crossing time of straight taxing, speed is set as SS=10m/s; function fun Trantime_cur is used for crossing time of turn a corner, turn speed is SC=5m/s; function fun Transtren_L is used for crossing time of center. We test a part of Flight time plan TABLE1.

Table: TABLE I. FLIGHT TIME PLAN

<table>
<thead>
<tr>
<th>number</th>
<th>Departure/arrival</th>
<th>ETOA/ETOP</th>
<th>gate</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>A</td>
<td>13:10:00</td>
<td>K31</td>
</tr>
<tr>
<td>P2</td>
<td>D</td>
<td>13:11:55</td>
<td>K32</td>
</tr>
<tr>
<td>P3</td>
<td>A</td>
<td>13:11:40</td>
<td>K33</td>
</tr>
<tr>
<td>P4</td>
<td>D</td>
<td>13:12:50</td>
<td>K34</td>
</tr>
<tr>
<td>P5</td>
<td>D</td>
<td>13:14:50</td>
<td>K35</td>
</tr>
<tr>
<td>P6</td>
<td>D</td>
<td>13:17:00</td>
<td>K36</td>
</tr>
</tbody>
</table>

Set average time, from runway to taxiway need 40s. Set two push-back position. Simulate the data as the following FIGURE 5.

The result prove that use of controller can improve efficiency of apron activities, control the apron conflict so that less delay.

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REFERENCES


