Abstract—Warehouse logistics play an important role in the system of modern logistics. The warehouse logistics with reasonable design and scientific management not only increase the process of material circulation through the enterprise, but also decrease the whole cost. This paper uses Petri Net to build modeling and use Flexsim to simulate entity demo, then to analyze and optimize the system. The results show that utilizing the Petri net and Flexsim software to simulate the warehouse logistics can easily find the bottleneck of building scheme, and the cost is low and the effect is visual display. So the simulation technique by the Petri net and Flexsim software can provide effective technical support for the warehouse logistics.

Keywords—Petri net; Flexsim; warehouse logistics; modeling and simulation

I. INTRODUCTION

Warehouse logistics is the use of space to store or warehouse, storage, handling and distribution of goods. Warehouse logistics activities mainly include cargo turnover, inventory, sorting, packaging, distribution and process information processing, and other content. Figure 1 is system schematic diagram of warehouse logistics. This paper use Petri net modeling and Flexsim entity simulation technologies on section links of warehouse logistics for modeling and simulation, and propose improved program to simulation warehousing project, optimize warehousing logistics system structure, to improve the working efficiency.

Fig.1. Warehouse Logistics System Schematic

II. BASED ON PETRI NET’S WAREHOUSING LOGISTICS SYSTEM MODELING

A. Petri net’s definition

Basic Petri net consists of five elements, its graph is represented as: \( PN = (P, T, I, O, M) \). Inside, \( P = \{ p_1, p_2, p_3 \} \) is called the limited storehouse collection; and \( T = \{ t_1, t_2, t_3 \} \) is called the limited changes collection; \( I \) is directed arc from storehouse to changes, also known as enter the arc collection; \( O \) is directed arc from changes to storehouse, also known as output arc collection; \( M: P \rightarrow \mathbb{N} \) is the network ID Petri, \( M_0 \) represents the system’s original state. A net with original identity with \( (PN, M_0) \) expressed. The difference between \( O \) and \( I \) \( A = O - I \) is called the association matrix.

Fig.2. Marked PN Formal Description

\[
P = \{ p_1, p_2, p_3 \} \\
T = \{ t_1, t_2, t_3 \} \\
I( p_1, t_1 ) = 1, I( p_1, t_2 ) = 0, I( p_1, t_3 ) = 0; \\
I( p_2, t_1 ) = 0, I( p_2, t_2 ) = 1, I( p_3, t_3 ) = 0; \\
I( p_3, t_1 ) = 0, I( p_3, t_2 ) = 0, I( p_3, t_3 ) = 1; \\
O( p_1, t_1 ) = 0, O( p_1, t_2 ) = 0, O( p_1, t_3 ) = 1; \\
O( p_2, t_1 ) = 1, O( p_2, t_2 ) = 0, O( p_2, t_3 ) = 0; \\
O( p_3, t_1 ) = 0, O( p_3, t_2 ) = 1, O( p_3, t_3 ) = 0; \\
M_0 = (1, 0, 0)^T.
\]

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\[
\begin{pmatrix}
1 & 0 & 1 \\
\end{pmatrix}
\]
\[
I = \begin{pmatrix}
0 & 1 & 0 \\
0 & 0 & 1 \\
0 & 0 & 1
\end{pmatrix}
\]
\[
O = \begin{pmatrix}
1 & 0 & 0 \\
0 & 1 & 0
\end{pmatrix}
\]
\[
A = O - I = \begin{pmatrix}
-1 & 0 & 1 \\
-1 & -1 & 0 \\
0 & 1 & -1
\end{pmatrix}
\]

**B. The changes in the performance of Petri net**

The changes in the performance of Petri net: the changes in the performance under motivation of the identification \(M\) will generate new identification \(M'\). \(\forall p \in P: M'(p) = M(p) - I(p, t) + O(p, t)\).

Say identification \(M'\) is reachable directly from \(M\). Motivation of a change is from its input storehouse remove token, then assign new produced token to each of its output location. As shown in Figure III in PN, after the motivation of performance \(t1\) in \(M0\) will generate new identification \(M1\):

\[
M1(p1) = M0(p1) - I(p1, t1) + O(p1, t1) = 1 - 1 + 0 = 0
\]
\[
M1(p2) = M0(p2) - I(p2, t1) + O(p2, t1) = 0 - 0 + 1 = 1
\]
\[
M1(p3) = M0(p3) - I(p3, t1) + O(p3, t1) = 0 - 0 + 0 = 0
\]
\[
M1(p4) = M0(p4) - I(p4, t1) + O(p4, t1) = 1 - 1 + 0 = 0
\]

**C. Using Petri net set up warehouse logistics system model**

In the case of material handling processes, suppose carry warehouse have 3 sets of transport plane, \(M1, M2, M3\), 4 sets of forklift, \(W1, W2, W3, W4\), and one set of transmission with high-altitude, \(Y1\). The removal process is divided into two phases transportation. Stage 1, high-altitude transport aircraft \(M1\) and \(M2\) transport goods individually. Stage 2, use high-altitude transport aircraft \(M3\) to transport goods that transported by \(M1\) and \(M2\). Through simulated analysis, this Petri net simulation system shown as Figure 4, library and definition of changes shown as Table I.

**Table I. Library and Definition of Changes**

<table>
<thead>
<tr>
<th>Name</th>
<th>Event Meaning</th>
<th>Name</th>
<th>Event Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>(P_1)</td>
<td>(M_1) Ready (T_1)</td>
<td>Arrival</td>
<td></td>
</tr>
<tr>
<td>(P_2)</td>
<td>(M_2) Ready (T_2)</td>
<td>(W_1) forklift loading of goods to the (M_1)</td>
<td></td>
</tr>
<tr>
<td>(P_3)</td>
<td>(M_1) Transportation (T_3)</td>
<td>(W_2) forklift loading of goods to the (M_2)</td>
<td></td>
</tr>
<tr>
<td>(P_4)</td>
<td>(M_2) Transportation (T_4)</td>
<td>(W_3) forklift loading of goods to the (M_1)</td>
<td></td>
</tr>
<tr>
<td>(P_5)</td>
<td>(M_3) Ready (T_5)</td>
<td>(W_4) forklift loading of goods to the (M_2)</td>
<td></td>
</tr>
<tr>
<td>(P_6)</td>
<td>(M_3) Transportation (T_6)</td>
<td>Transport over the (M_1) to (M_3)</td>
<td></td>
</tr>
<tr>
<td>(P_7)</td>
<td>(M_4) Available (T_7)</td>
<td>Transport over the (M_2) to (M_3)</td>
<td></td>
</tr>
<tr>
<td>(P_8)</td>
<td>(M_2) Available (T_8)</td>
<td>Complete the Uninstall</td>
<td></td>
</tr>
<tr>
<td>(P_9)</td>
<td>(W_1) Available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(P_{10})</td>
<td>(W_2) Available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(P_{11})</td>
<td>(M_3) Available</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 3: New Marking Graph

Fig. 4: Loading and Unloading Process Description Graph
III. FLEXSIM SIMULATE FUNCTION

A. Flexsim brief introduction

Flexsim is studied by America company Flexsim Software Production, using object-oriented technology. And it is a three-dimensional display of the discrete event system simulation software. It is the world’s first graphical modeling environment integration C++ IDE and compiler of the simulation software[3]. Flexsim can describe the whole process vividly and discovery problems in the process design clearly. It is widely used in industrial production, modeling, simulation and visualization of business processes.

B. Entity demonstration in Flexsim of Petri net model

Turn the model of Petri net into entity model of Flexsim, shown as Fig.5.

It is obvious to see that the bottleneck location of the whole system design is high-altitude transmission tape Y1. We can add one high-altitude transmission tape to remove the bottleneck of system, to improve the efficiency of the whole system, optimize the system.

IV. CONCLUSION

This paper after analysis influencing factors that influence enterprise warehouse logistics, use the Petri net to realize the modeling to the enterprise warehouse logistics. Then carries on the entity simulation through three-dimensional display’s discrete event system simulation software Flexsim, make the bottleneck of system design clear. Finally, by modifying the system parameters to achieve the purpose of optimizing the system.

REFERENCES