Layout of Guidance Signs in Passenger Hubs based on Passenger Activity Line

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Abstract. The layout of guide signs in passenger transport hubs is an important part of the traffic design of transport hubs. Firstly, based on the spatial layout and activity type of passenger transport hub, the functional areas are divided and the active passenger flows are extracted based on the passenger's moving path, so as to construct the active passenger flow network. Then the hierarchy, level and rank of the guide signs are analysed. Finally, taking a passenger station in Jiangsu as an example, the research can provide theoretical support for the layout of the guiding signs in the integrated passenger transportation hub.

1. Introduction

With the gradual improvement of the functions of passenger transport hub, the passenger flow activities are generated by passengers in the hub become more and more complex and the transfer flow is increasing. In the process of management and operation of passenger transport hub, the unreasonable layout of guide signs will make the passengers find their way in the hub longer, the efficiency of distribution in the hub is low and the supporting facilities are difficult to maximize their functions. Clear passenger flow activities and its internal spatial layout and reasonable guidance of passengers from the passenger flow point of view, which can help passenger save time to find the way in the hub, increasing the passenger's familiarity with the route in the hub, which is of great significance to improve the service level and operation efficiency in the hub. Therefore, reasonable layout of guide signs in passenger transport hub is the key to improve the overall service level of passenger transport hub.

In recent years, many scholars have studied the guide signs. Overseas research on guide signs started earlier and developed countries such as Britain and the United States have made a deep and comprehensive study on the text, color, graphic symbols of guide signs, which has certain reference experience[1,2]. In some large public places, the research on the location of guide sign setting is very extensive and many methods of guide sign setting are put forward[3,4,5]. In addition, Tam determines the location of the guide sign based on the maximum visual index and activity correlation[6]. Some domestic scholars use genetic algorithm or simulated annealing algorithm to solve the single objective optimization model of guide marking and determine the location and number of marking[7,8]. Lin Yu solved the multi-objective decision-oriented marking layout model by improved IFD-NSGA-II algorithm[9]. Wang Bingbing put forward the corresponding methods for setting information and location of guide signs through tracking observation method[10]. From the analysis of the current research situation at home and abroad, which can be seen that the layout of guide signs is mostly based on the spatial layout to determine the location of the signs and seldom proceeds from the psychological
needs of passengers and takes passenger flow as the starting point to lay out the guide signs. The core work of this paper is to propose a guide sign layout method based on passenger activities. Firstly, the hub is divided into functional areas. Passengers carry out different activities according to a certain logical order in the hub. Then, based on the passenger movement path, the passenger activity flow line is determined to form an active flow network, thereby constructing a guide sign layout model. On the basis of the above research, this paper realizes a case of guide sign layout for a city passenger hub. The model shows an effective and reasonable way to lay guide signs, which is beneficial to organizing passenger distribution and improving the efficiency of passenger flow organization in the hub.

2. Passenger activity flow and functional area division in hub

2.1. Passenger flow analysis
Passengers have different experience of facilities, environmental awareness and destinations in the hub, so they will pass through a series of different functional areas in the process of arriving at the destination. There are many activities in the functional areas. These activities form different paths in a certain order and form different passenger flows in the hub.

(1) Analysis of passenger flow activities
Passenger flow in hub can produce different activities in different areas. There are activities such as drop-in, leisure and entertainment, security check and so on in the inbound area; activities such as ticket selling, self-service ticket collection, leisure and entertainment, shopping, medical treatment, breast-feeding, consultation, inquiry, luggage storage, etc. in the inbound area; activities such as inbound and outbound ticket checking, inquiry, shopping, leisure and entertainment, luggage extraction, etc. in the outbound area node and transfer to other modes of transportation.

(2) Passenger flow analysis
Passenger flow in transport hub are generated in accordance with a certain sequence of activities. Passengers have different flows in the hub because of their different activities. There are three main types: inbound passenger flow, transfer flow and outbound flow.

A. Inbound passenger flow
Upon arrival, passengers on the inbound passenger flow will complete part of the activities in the inbound area, the activities in the hub and the activities in the passenger area. Mobile venues include station square, ticket hall, security inspection, waiting room, bus passage, platform and bus ride.

B. Transfer passenger flow
Transfer passenger flow is a turning point of transfer, which can take the pre-activity process of transfer passenger flow as the outbound passenger flow and the post-exit activity process as the inbound passenger flow. The transfer flow will complete the activities in the outbound area and activities within the hub.

C. Outbound passenger flow
The terminal of outbound passenger flow is the hub. After arrival, the outbound exit will be found as soon as possible to complete the outbound activities. Only the activities in the outbound area can be completed. The movement process includes passengers getting off, leaving the station, arriving at the exit, picking up the bag, standing in front of the square and changing to other modes of transportation.

2.2. Design and implementation of passenger flow network topology model
(1) Passenger flow analysis model definition
Set the active node of hub passenger flow network as N, where N is expressed as a set, N= {Inbound area node, Area node in hub, Passenger area node, Outbound area node} and it is shown in appendix A.

A passenger flow activity is defined as an ordered set L and defining the activities that passengers are indispensable in completing their travels are necessary activities, while the activities that are not necessary to complete in the process of travel are unnecessary activities. Passengers in the inbound passenger flow need to carry out activities such as inbound, security check, ticket collection, waiting
and taking a bus; passengers in the transfer passenger flow need to carry out activities such as outbound, security check, ticket collection, waiting and taking a bus and passengers in the outbound passenger flow need to carry out activities such as getting off, leaving the station and changing to other modes of transportation to leave.

For the inbound, transfer and outbound passenger flow, in addition to necessary activities, there are also some unnecessary activities, which will lead to many different passenger flows. Inbound passenger flow can be divided into two categories: passenger flow that only carry out necessary activities and passenger flow that also carry out unnecessary activities after necessary activities. Definition M represents all sets of activities, \( M = \{L_1, L_2...L_n\} \).

(2) Definition of network topology model

Graph is composed of a set of vertices with non-empty sets and edges between vertices. It is usually expressed as \( G(N, E) \), \( G \) as a graph, \( N \) as a set of vertices in \( G \) and \( E \) as a set of edges in \( G \). If the relationship set \( E(G) \) of \( G \) is ordered between \( V \) and \( W \) of vertex pairs \( (V, W) \), graph \( G \) is said to be a directed graph. In directed graphs, edge weights can represent the distance or cost from one vertex to another. Define the passenger flow network topology \( G = \{N, E, C\} \), where \( N = \{N_1, N_2...N_k\} \) is the vertex set, \( E = \{e_1, e_2...e_m\} \) is a set of edges and a set of corresponding non-negative weights.

(3) Implementation process of passenger flow network topology model

In the previous paper, the passenger flow activity set \( M \) is obtained by passenger flow analysis and the topological structure model of passenger flow network is introduced. In this section, the specific process and steps of building network topology model will be explained.

Step1: Prepare basic data. According to the layout of the internal structure, it is fully to understand the layout and connecting form of the functional area inside the hub to divide the functional area and analyse all the active nodes of the passenger flow inside the hub.

Step2: Analyse passenger flow. According to the activities completed by passenger flow in different areas of the hub, the passenger flow is analysed and the passenger flow activity set \( M \) is obtained.

Step3: Data files of network nodes and data files of network links are generated by \( M \). Activities are classified into first-level activities and second-level activities because of the different importance of activities within the hub. Level I activities are necessary activities and level II activities are not necessary activities.

Step4: According to the adjacency matrix and correlation matrix of passenger flow network, an algorithm is designed to automatically construct the topology map.

2.3. Division of functional areas in hubs

Based on the spatial layout of passenger transport hub, the layout of the hub is divided into different functional areas which named waiting area, leisure area, service area and security inspection area, in which waiting area mainly carries out waiting activities; leisure area mainly carries out shopping, leisure, dining; service area mainly carries out ticket sales, baggage storage, inquiries; security inspection area mainly carries out security inspection activities. There is a certain degree of independence among different functional areas. Passengers can carry out specific functional activities in the relevant functional areas. The activities in different functional areas do not affect each other. However, passengers need to travel through different functional areas in a certain order to complete the corresponding activities in the process of completing their travel passenger flows, so different functional areas are interrelated. Therefore, it is necessary to link different functional areas with guide information and take a city passenger hub as an example to divide functional areas which is shown in Figure 1.
3. Basic theory of guided signage

3.1. Hierarchy of oriented identification

In the passenger hub, based on the sequence of passenger travel activities and their psychological needs, the guide signs are divided into three levels. After passengers enter the hub, they usually want to master the overall information in the hub first, then the path information to the functional area and finally determine the specific location of their activities. The hierarchy of guide sign is divided as follows:

1. The first level is the transmission of layout information in passenger transport hub, so that passengers can be familiar with the distribution of functions in the hub and determine their own location, and have a holistic understanding of the hub space.

2. The second level is the transfer of information into the functional area. Based on the different purposes of passengers in the hub, the second level of identification guides the direction of passengers and has the function of diverting and gathering passenger flow.

3. The third level is the transmission of information about specific facilities, so that passengers can clearly locate their activities.

3.2. Oriented identification level

Based on the difference of the amount of information transmitted by the guide sign and its location, the guide sign is divided into the first, second, third and fourth levels.

1. The first-level guide sign has the greatest amount of information and they use words, symbols and other signs to convey path-oriented information to pedestrians. The first-level guide sign is mainly located at the entrance of the larger passenger flow and the hall or key node where the crowd gathers more.

2. The second-level guide sign undertakes the first-level guide identification system and the third-level guide identification system. Secondary guide sign system helps pedestrians to determine the path based on the first-level guide sign, more detailed and comprehensive display of specific environmental information and at the same time it can indicate the direction of pedestrians. Compared with the first-level oriented identification system, the second-level oriented identification system provides less information, but its service scope is broader and the transmission of environmental information is more direct and specific. Secondary guide sign system is usually located at the entrance of the area, the key nodes of the path of the area and the connection among the regional environment, which provides information guide services for pedestrians in the area.

3. The three-level guide sign is used to transmit the most specific guide information. The clarity of the information is at the highest level and it is the direct guide for pedestrians to reach their destination. The number of three-level guide sign is the largest, rich in content and diverse in form, including plane, three-dimensional, static, dynamic and other forms.

4. The four-level guide sign is a confirmation sign to help passengers to identify the location of facilities.
3.3. Directional marking order

In the process of passenger’s moving in the hub, the first step is to determine the direction and choose the right route. The second step is to observe the route to the functional area where the passenger needs to reach, and finally to determine the destination. In this process, in order to effectively transmit information to passengers, the layout of guide signs should be perfectly integrated with the spatial layout of the hub. According to the passenger travel process and the location of the functional areas and specific facilities in the hub, different levels of guide signs should be laid. Therefore, there should be a sequence in the process of laying guide signs.

In order to determine the order of the guide signs, the level of the guide signs should be determined based on the spatial location of the hub. Secondly, the amount of information transmitted by the guide signs should be determined and then the level of the guide signs should be defined. By determining the level of the guide signs, the order of the guide signs should be clarified.

4. Case analysis

In the hub, there are many paths and they are interconnected. Passengers need to make frequent decisions on the path according to their needs. Therefore, based on the location of the functional area in the hub, guide signs are laid to help passengers confirm their position and the location of the functional area they want to reach, thus reducing the difficulty of identifying their orientation. Secondly, it helps passengers to better plan the route, determine the route of travel, and quickly reach the location of the functional area that they need to reach, reducing passengers blindly finding their way in the hub.

According to the order of passenger travel activities and their psychological needs in the hub, the shortest path search among different functional areas is carried out. Based on the layout status of functional areas in a passenger hub which is in Jiangsu Province, a passenger flow network topology model is constructed. All functional areas are abstracted as nodes and all sections are abstracted as edges. For the long section in the hub, virtual nodes are set up to divide it into several sections. The waiting area is represented by the letter H, the leisure area is represented by the letter X, the service area is represented by the letter F, the security inspection area is represented by the letter A and P is represented by the virtual active node. An example is given to illustrate the distribution of the first floor functional area of a station. As shown in Figure 2, the yellow area represents the first level active area and the blue area represents the second level active area, so it is not necessary to carry out activities. Based on the function area distribution of the station, the route search is carried out to determine the path which the passenger is looking for in the hub.

![Figure 2. Passenger flow in hub](image)

Five virtual activity areas are set up in the figure, which are P1, P2, P3, P4 and P5. Among them, P1 is the virtual activity area inside the service area, and P2, P3, P4 and P5 are the virtual activity area between the service area and the waiting area. One-way communication of P1, P2, P3, P4, and P5 (green line in the graph), the virtual point P and the functional area in the figure are both bidirectional (red line in the graph). In the inbound process shown in the figure, passengers complete their inbound activities in a certain order. First, they arrive at the virtual activity area P1, then the virtual activity area is P2, P4,
and finally the virtual activity area is P3, P5. After passengers enter the hub, passengers in position P1 can reach F1, F4, F5, P2, P4, and bidirectionally communicate with F1, F4, F5, and are unilaterally connected with P2 and P4. Passengers in position P2 can reach F1, F6, F7, P3, X and bidirectionally communicate with F1, F6, F7, X and are unilaterally connected with P3. Passengers in P4 position can reach F1, F2, F2, P5, X and bidirectionally communicate with F1, F2, F3, X and are unilaterally connected with P5. Passengers at P5 can reach H2, H4, F2, and X, and communicate with H2, H4, F2, and X in both directions. Based on the location of the function area inside the hub, the path search is carried out, and some paths are shown in Appendix B.

According to the search results of the route, passengers in the hub are induced and the guide signs are laid. Among them, the level of the guide identification system is different, the amount of information transmission will be different. The higher the level of the guide identification, the more accurate the pointing is, and the shorter the service distance is accordingly.

According to the information hierarchy, service distance at different levels and model constraints, guide signs are laid out based on passenger flow lines. A first-level guide signs a laid at the entrance of the security inspection area, so that passengers entering the hub can have a holistic understanding of the layout of the hub. Secondary guide signs are laid on virtual area paths among the functional areas, informing passengers about the location of the functional area in front of them. The three-level guide signs are located in the virtual area and the corresponding functional area path, so that passengers can clearly define the specific orientation of the functional area so that passengers can reach their desired destination. The four-level guide signs are the confirmation signs, which confirm the location and facilities of the functional area. The layout results are shown in Figure 3. Route selection starts from the entrance to each functional point. By understanding the information needs of different passenger flows to the required points, the guide signs are hierarchically laid out. Considering the comprehensive coverage of information in the layout process, passengers will not lose their way in the process of route-finding, which provides a reference for the future layout of guide signs in the hub.

5. Conclusions
By analysing the spatial layout of the hub, this paper divides the functional areas, clarifies the passenger flows, constructs the passenger flow activity network and classifies the passenger flow activities in the hub into necessary activities and unnecessary activities. According to the different passenger flows, starting from the psychological needs of the passengers, virtual activity nodes and guide signs are set up. On the basis of the above research, this paper realizes a case of guide sign layout for a city passenger hub, which makes passenger travel demand get the most effective guide.

Acknowledgments
The work is supported by the National Natural Science Foundation of China (Grant No. 71771013, 51338008, 71621001, 71501011), and the Center of Cooperative Innovation for Beijing Metropolitan Transportation.
Appendices

A

Table 1. Passenger flow activity number in hub

| Area                | Num  | Name                          | Area                | Num  | Name                          |
|---------------------|------|-------------------------------|---------------------|------|-------------------------------|
| Inbound area node   | N1   | Drop off area                 | N2                  | Station square               |
| N3                  | Pre-station rest area          | N4                  | Security check               |
| N5                  | Sell ticket                     | N6                  | Self-service ticket collection|
| N7                  | Leisure area                      | N8                  | shops                         |
| Regional node in hub| N9   | Clinic                         | N10                 | Maternal and infant room      |
| N11                 | TOILET                           | N12                 | Waiting area                  |
| N13                 | Reception                        | N14                 | Baggage deposit               |
| N15                 | Ticket check                     | N16                 | Platform                      |
| N17                 | Ride                             | N18                 | Get off the car               |
| N19                 | Platform                          | N20                 | Check out                     |
| N21                 | Reception                        | N22                 | shops                         |
| N23                 | Pack extraction office           | N24                 | Transfer                      |
| N25                 | Departure                        |                      |                                 |

* “O” indicates the starting point of route; “D” indicates the terminal point of route.

B

Table 2. Example path

| Num | O | D | Route                          | Num | O | D | Route                          |
|-----|---|---|--------------------------------|-----|---|---|--------------------------------|
| 1   | A | H1| A-P1-F1-P2-F7-P3-H1            | 19  | A | H3| A-P1-F1-P2-F7-P3-H3            |
| 2   | A | H1| A-P1-F1-P2-P3-H1               | 20  | A | H3| A-P1-F1-P2-P3-H3               |
| 3   | A | H1| A-P1-F1-P2-X-P3-H1             | 21  | A | H3| A-P1-F1-P2-X-P3-H3             |
| 4   | A | H1| A-P1-F1-P4-X-P3-H1             | 22  | A | H3| A-P1-F1-P4-X-P3-H3             |
| 5   | A | H1| A-P1-F4-P4-F1-P2-F7-P3-H1      | 23  | A | H3| A-P1-F4-P4-F1-P2-F7-P3-H3      |
| 6   | A | H1| A-P1-F4-P4-F1-P2-P3-H1         | 24  | A | H3| A-P1-F4-P4-F1-P2-P3-H3         |
| 7   | A | H1| A-P1-F4-P4-F1-P2-X-P3-H1       | 25  | A | H3| A-P1-F4-P4-F1-P2-X-P3-H3       |
| 8   | A | H1| A-P1-F4-P4-P5-X-P3-H1          | 26  | A | H3| A-P1-F4-P4-P5-X-P3-H3          |
| 9   | A | H1| A-P1-F4-P4-X-P2-F7-P3-H1       | 27  | A | H3| A-P1-F4-P4-X-P2-F7-P3-H3       |
| 10  | A | H2| A-P1-F1-P2-X-P4-F2-P5-H2       | 28  | A | H4| A-P1-F1-P2-X-P4-F2-P5-H4       |
| 11  | A | H2| A-P1-F1-P2-X-P4-P5-H2          | 29  | A | H4| A-P1-F1-P2-X-P4-P5-H4          |
| 12  | A | H2| A-P1-F1-P2-P5-H2               | 30  | A | H4| A-P1-F1-P2-P5-H4               |
| 13  | A | H2| A-P1-F1-P4-F2-P5-H2            | 31  | A | H4| A-P1-F1-P4-F2-P5-H4            |
| 14  | A | H2| A-P1-F1-P4-P5-H2               | 32  | A | H4| A-P1-F1-P4-P5-H4               |
| 15  | A | H2| A-P1-F1-P4-X-P5-H2             | 33  | A | H4| A-P1-F1-P4-X-P5-H4             |
| 16  | A | H2| A-P1-F4-P4-F1-P2-X-P5-H2       | 34  | A | H4| A-P1-F4-P4-F1-P2-X-P5-H4       |
| 17  | A | H2| A-P1-F4-P4-F2-P5-H2            | 35  | A | H4| A-P1-F4-P4-F2-P5-H4            |
| 18  | A | H2| A-P1-F4-P4-P5-H2               | 36  | A | H4| A-P1-F4-P4-P5-H4               |

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