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Supernetwork Approach for Multimodal and Multiactivity Travel Planning

Feixiong Liao, Theo Arentze, and Harry Timmermans

Multimodal and multiactivity travel planning is a practical but thorny problem in transportation research. This paper develops an improved supernetwork model to address this problem. The supernetwork is constructed mainly in three steps: a personalized network is first split into two types of networks with all links mode-specified; these are then assigned to all possible activity-vehicle states by means of state spreading from the beginning activity state. Finally, these discrete networks are connected into a supernetwork by state-labeled transition links. The proposed supernetwork is easier to construct than previous proposals and reduces the size needed to embody all combinations of choice facets explicitly. It can be proved for any activity program that any tour is a feasible solution in this representation. Consequently, every transport and transition link can be defined mode and activity-state dependent; thus standard shortest path algorithms can be used to find the most desirable tour. A case study is presented to show that the supernetwork model can be applied in a real-time manner for practical travel planning.

Multimodal trips are a common travel phenomenon and are expected to become more important because of their expected contribution to sustainable urban transportation. The multidimensional nature of multimodal trips makes it hard to model multimodal traveling (1). The complicated activity behavior in executing multiple activities renders travel planning more difficult. In this study, the focus is on the concept of a supernetwork to model transport networks and land use in an integrated fashion, and the model is used to analyze the extent to which it supports the planning and implementation of daily activities.

“Supernetwork” is defined as a network of transport networks integrating different transport modes (2–4). Links interconnecting the physical networks represent transfer locations where individuals can switch between modes. An example is a train station in which an individual can park a car and board a train. Such extended networks allow researchers to model multimodal trips as paths through the supernetwork. Nagurney and coworkers proposed further extensions of supernetworks that also include links representing particular transactions between actors and telecommunications to model transportation, communications, and transactions involved in supply chains and other economic activities (5–7).

Inspired by Nagurney and coworkers (5–7), Arentze and Timmermans (8) developed an extension of the basic supernetwork

concept that integrates activity locations and multimodal transport networks. Their multistate supernetwork representation provides a potentially powerful framework for analyzing accessibility when accessibility is taken in its most fundamental meaning as the ease with which individuals can implement full activity programs. The cost of a least-cost path through a multistate supernetwork represents the effort associated with implementing an activity program. Such a measure takes into account multimodal and multiactivity patterns as well as the synchronization of transport networks and the land use system. A potential drawback of the approach is that the networks may become very large and possibly intractable because they need to incorporate as many copies of a physical network as there are possible states associated with the different stages of an activity program.

As Arentze and Timmermans argued, the approach may still be feasible when personalized supernetworks are constructed for one individual at a time (8). A personalized network allows not only representing preferences and perceptions individual specific but also a reduction to the relevant subset of a transport network. Thus, personalized supernetworks are not only more accurate, in the sense that they are tailored to the preferences and perceptions of an individual, but also reduce the size of the networks. This viewpoint has, however, not been validated, because a theoretical and quantitative analysis of supernetworks is lacking.

The purpose of this paper is to contribute to the further development of the supernetwork concept by providing such an analysis. Moreover, possibilities are explored of reducing supernetworks by improving the efficiency of the representation without reducing the representational power, and proofs of their proper working are provided. In doing so, the study makes a further step in the clarification of the theoretical properties and the operationalization of supernetworks for modeling and accessibility analysis of large-scale, integrated land use and transportation systems.

To achieve these objectives, the paper is structured as follows. First, basic concepts are briefly introduced and a formal description of a supernetwork model is presented. Next, the suggested improvements of the supernetwork representation are discussed and their properties are formally proved. A case study is carried out to indicate that the supernetwork model can be applied in a real-time manner for practical activity travel planning. Finally, a discussion of conclusions and future work ends the paper.

SUPERNETWORK MODEL

The supernetwork model is based on the fact that the costs of any kinds of links are mode and activity state dependent and personalized. State dependent means that link costs may vary with the current activity and mode state. Personalized refers to an individual’s preference, perception, and knowledge of the links. In a supernetwork,

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the nodes denote real locations in space and every link represents an individual's action such as walking, cycling, driving, parking or picking up a car, boarding or alighting a bus or train, and conducting a specific activity. Thus, link costs can be readily defined state dependently and individually. The rest of this section discusses how a supernetwork based on these concepts is constructed. The following defines an activity program as a plan involving an individual leaving home with at most one private vehicle to conduct at least one activity and returning home with all activities conducted and all private vehicles at home.

Activity and Vehicle State

In this model of an activity program, every activity has only two states: either not conducted or conducted. An activity state is a possible combination of states across all activities. In practice, an activity might include several subactivities. For example, shopping may involve first shopping at a supermarket and then dropping the products somewhere. Such activities are decomposed into related activity units so that each of them involves a single location and a continuous time period. As a result, every activity has merely two states and there may be some implied sequence among the activity units belonging to a same broader activity. Therefore, if there are N activities, a possible activity state S^* can be described as N lengths of permutation of 0 and 1, $S^* = \dots s_i^* \dots, s_i \in \{0, 1\}$, where i is an index of activity and $s_i^* = 0$ denotes activity i not conducted or conducted.

Furthermore, the model allows different specifications of an activity program concerning flexibility of the activity sequence. For any two activities, if their sequence relationship is "immediate after," the sequence is "strict"; if just "after," it is "nonstrict"; otherwise, there is no sequence. If there is no sequence among N activities, the number of states $|S^*|$ equals 2^N . If there is a strict sequence among all activities whether inherently or individually, then $|S^*| = N + 1$. If the program includes two strict sequential parts, then $|S^*| \leq (N/2 + 1)$. In most real activity programs, N is a very small number. In most cases, N will not be larger than 3. Even if N may sometimes reach 5 or 6, the individual will consciously specify sequences on the basis of preference besides the inherent sequences (9). Thus, it is a safe assumption that in most situations the number of activity states is not larger than 20.

Simultaneously, a vehicle state defines where private vehicles are during the execution of the activity program. Because the individual goes out with at most one private vehicle, a possible state might fall into one of three situations: (a) all private vehicles stay at home, (b) the chosen private vehicle is in use, or (c) it is parked at a certain parking location outside. Therefore, a vehicle state $S^\rightarrow$ can be written as

$$S^\rightarrow = \dots s_j^\rightarrow, \dots, s_j^\rightarrow \in \{-1, 0, 1, 2, \dots, p_j\}$$

where

- j = index of private vehicle,
- $s_j^\rightarrow = -1$ denotes that private vehicle j is staying at home,
- $s_j^\rightarrow = 0$ private vehicle is in use, otherwise, parked somewhere, and
- p_j = number of parking locations for j .

Hence, if there are M types of private vehicles and going out on foot is allowed, the number of possible vehicle states is given by

$$|S^\rightarrow| = 1 + \sum_j p_j + M$$

Assuming a three-way classification of going-out modes, an individual can go out on foot, by bike, or by using an available car. If by foot, no parking locations are involved; if by bike, the parking locations are normally designated to activity locations or transit locations near home; or else if by car, a robust heuristic is needed to reduce the choice set and find one or two parking locations near activity and transit locations. In general cases, for a chosen going-out mode, the number of vehicle states is within 2 times N .

The activity-vehicle state is the intersection of activity state and vehicle state, which demonstrates the situation in regard to which activities have been conducted and where the private vehicles are.

Multimodal Personalized Network

It is necessary to specify link costs state dependently, but it is redundant to consider the whole transport network. Given an activity program, only an activity-related subnetwork is useful for the individual, which is considerably reduced from the raw transport network. In Arentze and Timmermans, a single personalized network is extracted before the supernetwork is constructed (8). As shown below, the personalized network is further split, which can contribute to expressing the choice facets more clearly and reducing the scale.

Two types of networks are extracted in regard to going-out modes. One is the private vehicle network (PVN), which is accessible only by the chosen private vehicle. PVN contains the home location, parking locations, a few key locations, and links that connect all locations. Obviously, if the individual does not consider going out by private vehicle, a PVN is not needed. The other is the public transport network (PTN), which can be accessed by foot and other modes provided by public transport. PTN includes the home location, activity locations, parking locations, auxiliary transit locations, and mode-specified links that connect all locations.

PVN and PTN can be considered as bidirected and sparse graphs as they are extracted from road/service networks. Meanwhile they are connected because any nodes in PVN and PTN are reachable from home. Because PTN is a multimodal network, if any node induces a mode change, extra bidirected links are added to denote boarding-alighting transition links. For example (see Figure 1), Link 2→6 denotes boarding and Link 6→7 denotes alighting and then boarding. This extension seems to make the PTN large again. However, on the basis of the authors' observations, a PTN never has more than 40 nodes for three activities by pseudo-admissible heuristic extraction.

Extended in such a way, every link in PVN and PTN is mode specific. When copies of PVNs and PTNs are assigned to different activity states, PVNs and PTNs can be defined mode and activity state dependent.

Supernetwork Representation

To capture all choice facets for an activity program, the next step is to connect all PVNs and PTNs in different states through transition links, which cause entering different networks. A transition link represents parking-picking up a private vehicle or conducting an activity. Using the former implies an exchange between PVN and PTN, whereas using the latter leads to entering networks of different activity states.

If travel is not made by a private vehicle, no parking or picking-up transition link is involved. In the case of private vehicle m with

FIGURE 1 Example of extra links for mode change.

p_m parking locations, the transition between different vehicle states can be realized by one PVN and p_m PTNs. Links from PVN to PTN are parking links, and vice versa picking-up links (see Figure 2). The bold lines indicate that the individual picks up the private vehicle at parking location P_1 , travels through PVN, and parks the private vehicle at parking location P_3 to conduct the next activity nearby. Compared with each parking or picking-up link resulting in a full reduced network in Arentze and Timmermans (8), a single PVN is added to erase all unnecessary copies of PTNs appearing in the vehicle state when a private vehicle is in use. Similarly, doing so reduces the size by erasing unnecessary copies of PVNs in the vehicle states when the private vehicle is parked.

Activity transition link occurs when any activity state alters from 0 to 1. Let S_k^* denote the set of activity states in which k activities have already been conducted, and $S_{k,m}$ ($1 \leq m \leq |S_k^*|$) represent the m th element of the set. If $S_{k+1,n}$ is reachable from $S_{k,m}$ by conducting activity i , there are activity transition links between these two states. In particular, if activity i can be conducted at l_i different locations, l_i links are added in each pair of PTNs appearing in one vehicle state and two activity states (see Figure 3). A straightforward way that exhibits all of the activity transition in the whole activity state space is to start from $S_{0,1}$ and spread transition links to S_1^* , then from S_1^* to S_2^* , and so on until S_{N-1}^* to S_N^* .

Another improvement of the proposed supernetwork representation is that it is constructed separately in regard to the choice of going-out modes. In Arentze and Timmermans (8), all possibilities are contained

in one scheme, in which one least-cost path will be found. In fact, links from different going-out mode induced networks can never be in one feasible path. Thus, constructing them separately does not affect optimality. The least-cost algorithm can be implemented in each going-out mode-based supernetwork, which can not only output different going-out mode specific least-cost paths, but also surprisingly cut down computing costs in real-time settings given the fact that there is no absolute linear-time shortest path algorithm so far.

On the basis of the components analyzed above, for each going-out mode, the steps for a supernetwork representation can be described as follows:

- Step 1. Extract PVN and PTN, and extend PTN with boarding and alighting links, $k = 0$.
- Step 2. For every activity state in S_k^* , connect PVN and PTNs by parking or picking-up links if PVN exists.
- Step 3. For any activity state in S_{k+1}^* , if it can be reached by one from S_k^* , connect PTNs by activity transition links.
- Step 4. $k = k + 1$, if $k < N$, go to Step 2; otherwise, stop.

Thus, the union of all the going-out mode-based supernetworks is the final supernetwork. Figures 4a and 4b are illustrations of an activity program that includes two activities and two going-out modes, that is, by foot and car. H and H' denote home at the beginning and ending activity state, respectively; A_1 and A_2 denote locations for Activity 1 and 2; and P_1 and P_2 , parking locations for the car. The bold tour in Figure 4b represents the tour in which the individual leaves home by car, parks car at P_1 , and travels in PTN to conduct A_1 ; then picks up car at P_1 , drives car again, parks at P_2 , and travels in PTN to conduct A_2 ; and last picks up car at P_2 and returns home with all activities conducted. Along this tour, every link denotes a unique action and all choice facets are explicit.

It can be observed that all PTNs in the same activity state seem identical, whereas PTNs from different activity states tend to be different. However, merging the same PTNs into one brings the risk of contradictory tours. For example (see Figure 5), the tour marked with the bold links is infeasible; the individual cannot pick up the car at P_2 because it is parked at P_1 . It is because of these different PTNs coupled with other components that a supernetwork can embody all choice facets concerning multimodal and multiactivity travel.

The supernetworks are constructed separately in regard to going-out modes. Therefore, all the going-out mode-based supernetworks possess the same characteristics. In each of them, it is argued that any path P from H to H' is a feasible solution to the multimodal and multiactivity travel planning problem.

FIGURE 2 Example of parking or picking-up links.

FIGURE 3 Example of activity transition links.

FIGURE 4 Supernetwork representations: (a) by foot and (b) by car.

FIGURE 5 Example of infeasible tour.

Lemma 1

In every going-out mode-based supernetwork, there exists at least one path from H to H'; furthermore, any path P from H to H' is feasible.

Proof. Consider the private vehicle mode first. In each activity state, PVN and PTNs are connected by parking or picking-up links at parking locations. Because PVN and all PTNs are connected, the horizontal units of a supernetwork are connected. Similarly, there are transition links between reachable PTNs. The last activity state must be reachable by the first one; otherwise, the activity program is erroneous. Therefore, the vertical units of a supernetwork are connected. In sum, the whole supernetwork is connected and thus there exists a path at least from H to H'.

A feasible path satisfies two conditions: (a) no contradiction in activity sequence relationships and parking-picking logic along the path and (b) all activities have been conducted and the private vehicle at home is at the end H'.

During the supernetwork construction, activity transition links occur only when activity states are one way reachable, so that the activity sequence relationship is naturally satisfied. In addition, in every activity state, PTNs are independent and correlated only by means of PVN. To conduct an activity, the individual must have the private vehicle parked in PVN first and enter a PTN specified by the corresponding vehicle-activity state. Once the activity is conducted, the activity state is updated. If it is the final activity state, the individual will pick up the private vehicle in PVN and return home. Otherwise, the individual has two options to conduct the next activity: either staying in the PTN of the same vehicle state or entering another PTN of a different vehicle state by going through the PVN. The whole process ensures that no conflict of parking or picking-up logical relationship will occur.

The endpoint H belongs only to the final activity state with all activities conducted, and it can be accessed only through the final PVN so that the private vehicle must be at home in H'. Therefore, any path from H to H' is feasible.

Similarly, if by foot, there is no PVN and only one PTN, the argument still holds.

end of proof

Size of Supernetwork Representation

The nice properties of a supernetwork come at the cost of a substantial increase in the scale of networks. However, it is not difficult to calculate the size of the supernetwork for an activity program because all links and networks are well-ordered as activity $\times$ vehicle state matrices. Assume that the sizes of personalized networks are constant,

then the size of a supernetwork depends on how many copies of the personalized networks and transition links there are.

Consider an activity program with N activities, l_i activity locations for activity i , M types of private vehicles plus by foot mode, and p_j parking locations for private vehicle j . If there is no sequence among activities, the number of copied networks Q_c is

$$Q_c = 2^N \times \left[1 + \sum_{j=1}^M (1 + p_j) \right] \quad (1)$$

where 2^N is the number of activity states and the rest is the number of vehicle states. This formula can be reduced to $|S^*| \times |S^+|$. The number of parking or picking-up transition links Q_p is

$$Q_p = 2 \times (2^N - 1) \times \sum_{j=1}^M p_j \quad (2)$$

The reason for decreasing 1 is that there are only parking links in the first activity state and only picking-up links in the last. The number of activity transition links Q_a is

$$Q_a = \sum_{i=1}^N l_i \times 2^{N-1} \times \left(1 + \sum_{j=1}^M p_j \right) \quad (3)$$

These calculations are related directly to the sequences of activities. If specifying strict sequences for all activities by index, then

$$Q_c = (N + 1) \times \left[1 + \sum_{j=1}^M (1 + p_j) \right] \quad (4)$$

$$Q_p = 2 \times N \times \sum_{j=1}^M p_j \quad (5)$$

$$Q_a = \sum_{i=1}^N l_i \times \left(1 + \sum_{j=1}^M p_j \right) \quad (6)$$

The formulas are not as simple as above when partly strict or non-strict sequences are specified, but it is certain that they are somewhere in between these two situations. Taking the case in Arentze and Timmermans for example (8), N_1 and N_2 , activities without and with product, respectively, there are $N_1 + 2 \times N_2$ activities after activity decomposition. If $l_i = 1$ for all i , the formulas are

$$Q_c = 2^{N_1} \times 3^{N_2} \times \left[1 + \sum_{j=1}^M (1 + p_j) \right] \quad (7)$$

$$Q_p = 2 \times (2^{N_1} \times 3^{N_2} - 1) \times \sum_{j=1}^M p_j \quad (8)$$

$$Q_a = \sum_{k=1}^{N_1+N_2} T(k) \times k \times \left(1 + \sum_{j=1}^M p_j \right) \quad (9)$$

where

$$T(k) = \sum_{\substack{\min(k, N_1) \\ \max(0, k-N_2)}} \frac{N_1!}{i! \times (N_1 - i)!} \times \frac{N_2!}{(k-i)! \times (N_2 - k + i)!} \times 2^{k-i} \quad (10)$$

The original problem for multimodal and multiactivity travel planning can be reduced to the traveling salesman problem in polynomial time, which is a famous NP-complete problem in combinatorial optimization. In other words, the original problem belongs to the NP-hard class. Fortunately, in reality, not every NP-hard problem is really that hard.

ACTIVITY TOUR FINDING

In the supernetwork, any node denotes a real location, and any link is either a transport link, which always causes a change of location, or a transition link, which never causes a change of location but a change of mode or activity state. Combined with the fact that links in PVN or PTN are all mode specific, each transport link has its own activity state and mode, and each transition link has its activity state rather than mode.

The generalized link cost pattern in Arentze and Timmermans is adopted (8) (which reveals the disutility on all links) for transport link, described simply as

$$cp_l = f(\bar{\omega}_{m,s}(l), t_l, d_l, p_l) \quad (11)$$

where cp_l is generalized cost of transport link l and $f(\bar{\omega}_{m,s}(l), t_l, d_l, p_l)$ denotes function of activity state, mode, distance time elapse, and road preference, respectively. Likewise, the link costs for transition links are defined as

$$cs_n = h(\pi_s(n), t_n, c_n, p_n) \quad (12)$$

where cs_n is generalized costs of transition link j and $h(\pi_s(n), t_n, c_n, p_n)$ denotes a function of activity state, service time, service cost, and location preference, respectively.

As the functions above suggest, all link costs are state dependent. For each transport link, if the activity and mode state are known, so are the other parameters of the link cost. It signifies that transport link costs are only state dependent. Transition link costs can also be recognized as only state dependent if other parameters are thought of as state dependent. This assumption is logical and possible as long as the individual specifies previous expected values to service costs and time. With all link costs only state dependent, the following can be argued.

Lemma 2

In each going-out mode-based supernetwork, if all link costs are only state dependent, the path P found by the Dijkstra algorithm is the least-cost path.

Proof. If link costs depend only on states, the costs of either transport or transition links are known in any known states. Because the supernetwork represents all feasible activity-vehicle states, all link costs in the supernetwork are known in advance. Given that link costs are defined as a disutility, link costs cannot be negative. Thus, the Dijkstra algorithm can find the least-cost path, and it is acyclic (10).

end of proof

Thus, the single-source (H) single-link (H') shortest path algorithm fits the supernetwork model. Theoretically, the time complexity for the Dijkstra algorithm with binary heap is $O((m+n) \times \log n)$, where m and n denote the number of links and nodes; with Fibonacci heap, the time complexity is $O(m+n \times \log n)$ (10).

Because PVN and PTN are both sparse, the supernetwork is also sparse with $m = O(n)$.

In addition, some service costs may also be time dependent because services are often distributed or associated with time. One special structural property concerning time-dependent links is called first-in, first-out (FIFO) (11). If all links in a network obey FIFO, the network exhibits the FIFO property, for which the label-setting method can also find the optimal tour. According to Lemma 2, if all links are only state dependent, the link costs are constant so that the supernetwork is a special case of an FIFO network. However, if any time-dependent link such as parking or boarding transition link brings the non-FIFO property, the supernetwork is a non-FIFO network, for which to find the least-cost tour is another kind of NP-hard problem. Fortunately, on the basis of some special reductions, a non-FIFO time-dependent link can be converted into FIFO again (12).

On the basis of the analysis of quantities of supernetwork components, an upper bound approach analysis case can explain the feasibility of the algorithm for practical use. Suppose that there are six activities, 20 activity states, 10 parking locations for one private vehicle, 20 nodes in PVN, and 80 nodes in PTN. Then, the number of nodes in one private vehicle-based supernetwork is 16,400 in total. For sparse graphs of such scale, the algorithm takes only a very small fraction of a second on a modern PC. Even with several choices of private vehicle, the whole computation time is within a second. In other words, the supernetwork model can react in a real-time manner for practical activity programs or can be applied in large-scale simulations.

All in all, the suggested supernetwork model suffices for general individual multimodal and multiactivity travel planning. Provided with a large set of real activity programs related to a simulated population, the supernetwork model can be tailored for accessibility analysis of integrated land use and transportation systems on a large scale for spatial or transportation planning.

CASE STUDY

In this section a case study is presented to indicate the efficiency of the supernetwork model for multimodal and multiactivity travel planning. The supernetwork model is executed in Matlab in a Windows environment running on a PC with Intel Core 2 Duo CPU E8400 @ 3.00 GHz 3.21G RAM. The case is selected from Arentze and Timmermans and concerns travel planning in the Almere-Amsterdam corridor of the Netherlands (8). Figure 6 is the personalized physical network, which is a symmetrical bidirected graph. For simplicity and without loss of generality, consider the case in which an activity program contains two activities (working, W, with one location and shopping, A, with two location alternatives) and one private vehicle (car with five parking locations, P), and that car is the only going-out mode considered and is the place for dropping off products.

Assume that the land use for activity locations and parking locations is as described in Table 1. Moreover, the disutility of boarding link at all stations is assigned a fixed quantity of five, and there is zero disutility for picking-up and alighting links, which are just marks of change of mode. Assume further that the activity state will not affect the disutility on the links, except that disutility will double on walking mode-specific links after shopping as a result of carrying bags, which is a reasonable assumption in daily life.

FIGURE 7 PVN and PTN: (a) extracted PVN for car and (b) extracted PTN with boarding and alighting links.

within the bold part has changed to another. In detail, after alighting at Station 3, the individual will not board Line 1 but will walk directly to the parking location (Node 2) through links (3, 4), (4, 1), and (1, 2). The total disutility on the new tour is 714. If the person changes the disutility again, the algorithm will again react in a real-time manner and provide the optimal tour.

CONCLUSION AND FUTURE WORK

In this paper the formal properties of the supernetwork model were analyzed, and the upper bounds of the size depending on assumed characteristics of the activity programs were derived. The analysis indicated that the size for personalized supernetworks stays well within reasonable bounds for realistic dimensions of activity programs. Furthermore, methods were developed to reduce the size of supernetwork representations without compromising the representational possibilities. It was shown that efficiency can be improved significantly

so that larger problems can be handled with the same computing capacity. The approach based on a realistic case of a multimodal and multiactivity program was illustrated. Thus, the approach is applicable. The paper has made a next step in developing operational supernetwork models for accessibility analysis. Remaining steps concern the representation of time-dependent and time-window services that can represent the constraints of the transport and land use system and the definition of link cost functions that can represent actual preferences and rules for the selection of relevant nodes and links for tailored supernetwork representations. These steps will be considered in future research.

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TABLE 2 Optimal Activity–Travel Tour

Link		Transport Link (yes?)	Mode	Transition Link (yes?)	Behavior	Disutility
Start Point	End Point					
1 - PVN	2 - PVN	Yes	Car		Departing	2
2 - PVN	2 - PTN			Yes	Parking	10
2 - PTN	2 - PTN			Yes	Boarding	5
2 - PTN	3 - PTN	Yes	Local train 1		Transferring	4
3 - PTN	8 - PTN	Yes	Local train 1		Transferring	30
8 - PTN	9 - PTN	Yes	Local train 1		Transferring	5
9 - PTN	9 - PTN			Yes	Alighting	0
9 - PTN	14 - PTN	Yes	On foot		Transferring	1
14 - PTN	11 - PTN	Yes	On foot		Transferring	3
11 - PTN	11 - PTN			Yes	Working	540
11 - PTN	12 - PTN	Yes	On foot		Transferring	3
12 - PTN	12 - PTN			Yes	Shopping	60
12 - PTN	13 - PTN	Yes	On foot		Transferring	2
13 - PTN	13 - PTN			Yes	Boarding	5
13 - PTN	3 - PTN	Yes	Express train 1		Transferring	35
3 - PTN	3 - PTN			Yes	Alighting and boarding	5
3 - PTN	2 - PTN	Yes	Local train 1		Transferring	4
2 - PTN	2 - PTN			Yes	Alighting	0
2 - PTN	2 - PTN			Yes	Dropping	0
2 - PTN	2 - PVN			Yes	Picking	0
2 - PTN	1 - PVN	Yes	Car		Returning	2

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