Development of a Train Operation/Passenger Behaviour Simulation System

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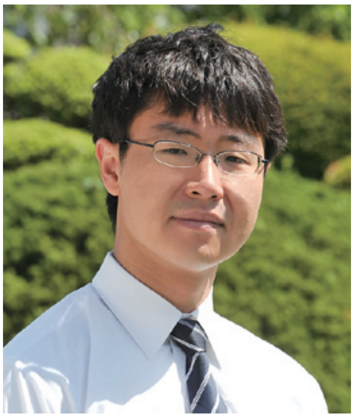

Train timetables are core products for the railway company, and they should be evaluated from the viewpoint of passengers. For this purpose, it is necessary to estimate the conditions of train operation and passenger behaviour in detail from the origin to the destination, i.e., which trains each passenger selected: at which stations he/she changed his/her train: how long it took for him/her to arrive at their destination: and what degree of congestion he/she experienced during the trip. In urban areas with high levels of commuter traffic in particular, concentration of passengers in certain trains causes delays of the train, which leads to further passenger concentration in the trains, thereby generating a vicious circle. To evaluate timetables effectively, therefore, it is essential to estimate precisely the actual state of train operation including the aforementioned snowballing effect of passenger concentration.

In the circumstances, therefore, RTRI has developed "train operation/passenger behaviour simulation system" to estimate the state of train operation (train arrival/departure time and degree of congestion) and the behaviour of each passenger (selection of the first train or following trains at an interchange station, if any) when a particular train timetable is implemented.

This system conducts three principal estimations: (1) each passenger's choice of trains, (2) congestion of each train and (3) train arrival/departure time (Fig. 1). The first estimation determines the trains selected by each passenger from the boarding to the alighting station based on passenger data collected at automatic ticket gates and other sources, while reflecting each passenger's desire, such as reaching the destination as early as possible or minimize the times of changing trains. The second estimation summarizes the information about the trains selected by each passenger, and calculates the number of passengers on board along with the number of boarding/alighting passengers at intermediate stations. The third estimation calculates the time required for boarding/alighting at each station based on the estimated number of boarding/alighting passengers, thereby calculating the delay of each train due to the boarding/alighting action taken by passengers. These three estimations are conducted in parallel on a time series basis starting with the first train of the day. Through this process, this system represents the aforementioned complicated phenomenon whereby the delay of an overcrowded train at a certain station increases at the successive stations, thereby making it possible to estimate the state of train operation closer to what actually happens in practice.

Figure 2 shows the screen of this simulator. The display of train timetable highlights the trains estimated to be overcrowded and/or delayed, while the display showing the status of stations indicates the number of passengers waiting on the platform at each station. This allows the operator of the simulator to easily assess the results of the simulation.

Figure 3 illustrates the comparison between an existing train timetable for a specific route providing commuter services and a revised one. The revised one is designed to make express trains stop additionally at Station 4 to improve the convenience of Station 4 passengers. In contrast, however, those who do not use station 4, for example those travelling from Station 1 directly to Station 6, may consider the revised one to be less convenient. Therefore, we want to analyze the result of the simulation to study how many passengers feel the revised one to be convenient or inconvenient as a whole (Fig. 4). For this purpose, we adopt the concept of "disutility" as a comprehensive index for evaluation. This is calculated from the travel time experienced by each passenger, waiting time, the number of changing trains and the degree of overcrowding. As a result, it has been proved that there are about 3.5% more passengers who feel the revised one to be convenient compared with those who feel otherwise.

This article has introduced a train operation/passenger behaviour simulation system. In the future, we are planning to apply this system for the evaluation of a train rescheduling plan to be adopted under disturbed train operation.

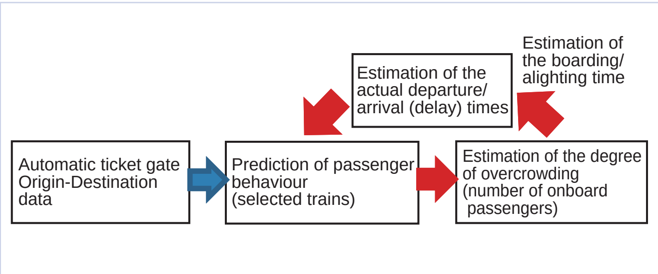

Fig. 1 Flow of simulation

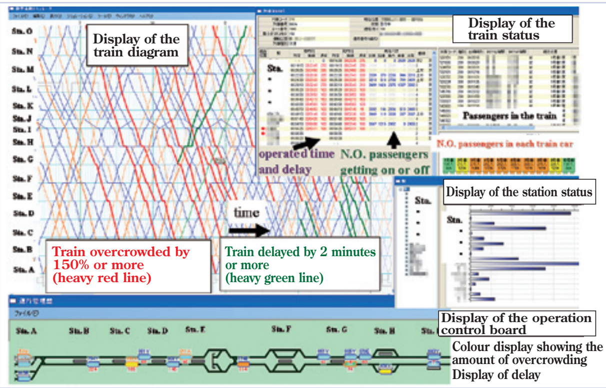

Fig. 2 Screen of simulator

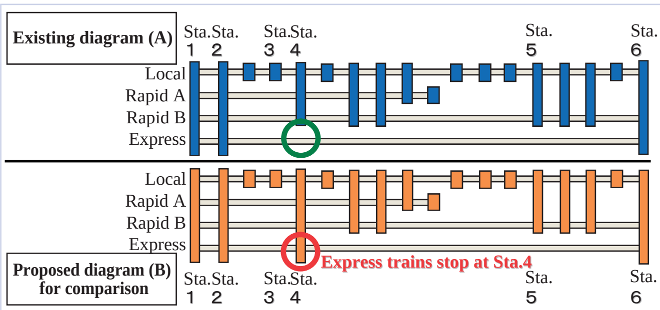

Fig. 3 Comparison of train operation diagrams

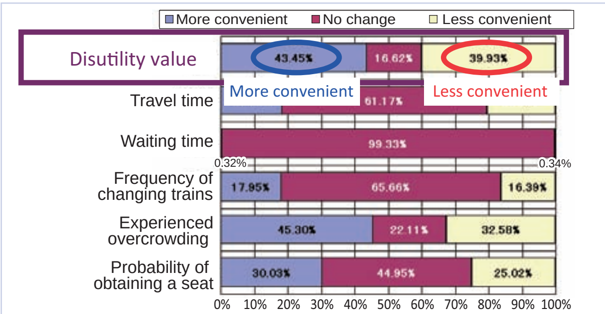

Fig. 4 Results of comparison