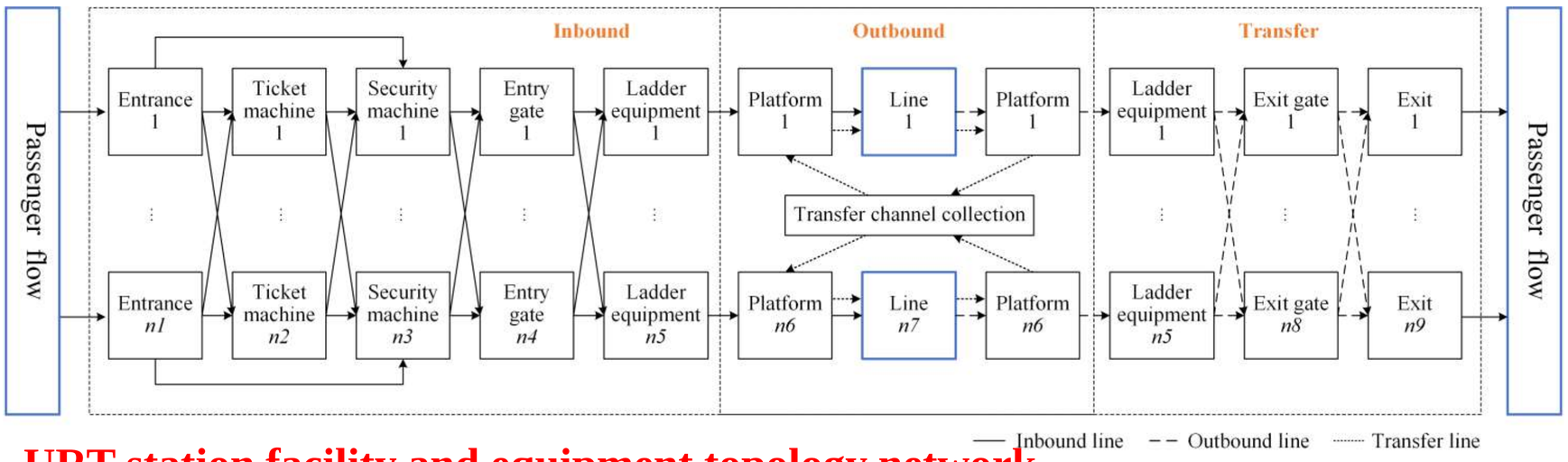
Resilience Assessment of Urban Rail Transit Stations

Xiaowei Liu(lxw@my.swjtu.edu.cn) Jinqu Chen(chenjinqu@my.swjtu.edu.cn) Xu Yan(yanxu@my.swjtu.edu.cn) Qiyuan Peng(qiyuan-peng@swjtu.edu.cn)

ABSTRACT: Combined with the topology network of the station facilities and equipment, a calculation method of passenger travel time in the station is proposed, based on queuing theory and stochastic user equilibrium assignment. Based on the service level without disruption, a time-varying performance indicator is constructed from the perspective of passenger travel efficiency. On this basis, station resilience under four types of daily disturbances can be evaluated, including passenger flow disturbance, facility and equipment disturbance, walking path disturbance, and train operation disturbance. A case study on Simaqiao station of Chengdu Metro is carried out.

Evaluation model of URT station's accessibility reliability



URT station facility and equipment topology network

Nodes in Figure represent device points $V=\{v_i\}$. Edges represent walking paths between device points $E=\{e_{ij}\}$.

Passenger walking path selection model

➢ **Passenger travel time at the station**

Passengers' travel time at the station is composed of walking time, equipment service time waiting time at the platform.

The BPR road resistance function is used to calculate the actual walking time $T_{ij}(t)$ of passengers on edge e_{ij} at the time t.

$$T_{ij}(t)=l_{ij}\times(1+a\cdot(\frac{x_{ij}^t}{c_{ij}})^b),\ i\in u_m, j\in u_{m+1}$$

The queuing model (M/M/S/∞/∞/FCFS) is used to calculate the time $T_i(t)$ for passengers to receive services at various equipment.

$$T_i(t)=\frac{\rho_i^t(s_i\rho_i^t)^{s_i}}{\lambda_i^t\cdot s_i!(1-\rho_i^t)^2}\cdot P_i^t(0)+\frac{1}{\mu_i}$$

The waiting time t_w^r at the platform is calculated according to the time passengers arrive and leave the platform.

$$t_w^r=t_d^r-t_a^r, r\in N_z, z=1,2$$

➢ **Passenger walking path selection**

1. Normal operation

We adopts the Stochastic User Equilibrium (SUE) passenger flow allocation model to calculate the walking path choices of passengers in URT stations.

$$p_{ij}(t)=\frac{\exp(-\theta w_{ij}(t))}{\sum_{e_{ij}\in K_{v_i-u_{m+1}}}\exp(-\theta w_{ij}(t))},\ i\in u_m, j\in u_{m+1}$$

2. Under disturbance

Passengers will decide whether to continue to stay at the station for URT travel according to the additional waiting time required, their tolerance, and the use of the station capacity.

(1) Option 1: stay at the station

(2) Option 2: leave the station

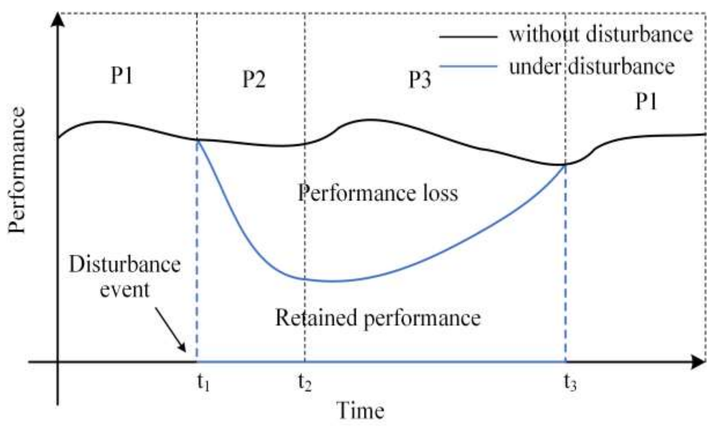
Resilience Assessment of URT Station

➢ **Disturbance scene**

Passenger flow disturbance, facility and equipment disturbance, walking path disturbance, train operation disturbance.

➢ **Performance of the URT station**

We proposes the transportation performance indicator of the URT station, which is measured by the ratio of the passenger's in-station travel time under undisturbed operation to that under disturbance.

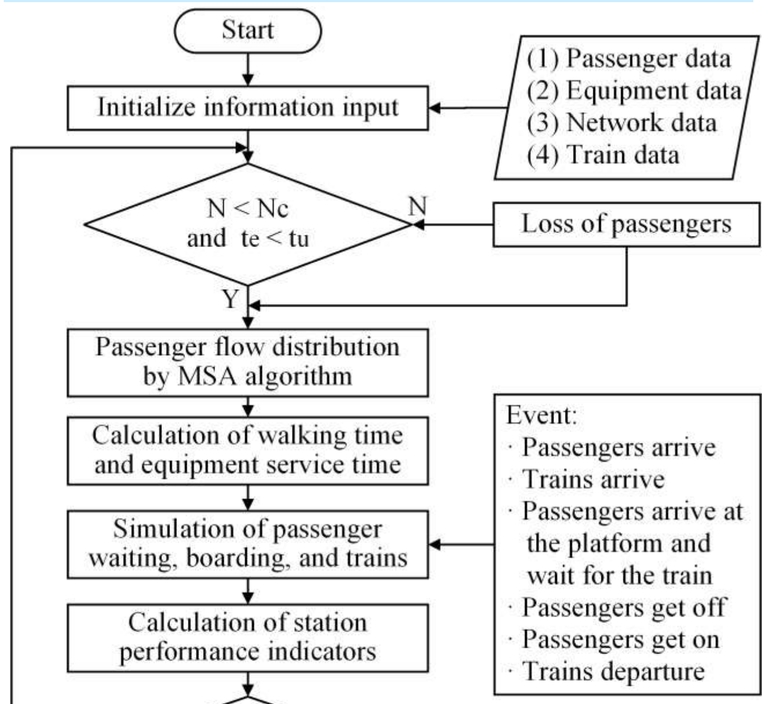


$$Q(t)=\frac{T_0(t)}{T(t)}\quad R=1-\frac{\int_{t_1}^{t_3}(Q_0(t)-Q(t))dt}{\int_{t_1}^{t_3}Q_0(t)dt}$$

➢ **Resilience of the URT station**

Resilience R is measured by retained performance after disturbances.

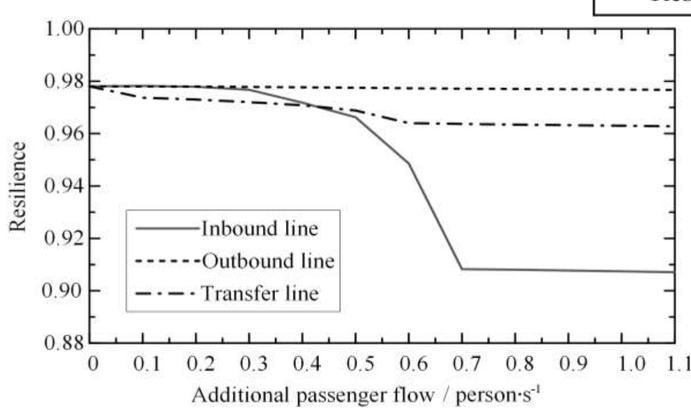
SOLUTION ALGORITHM

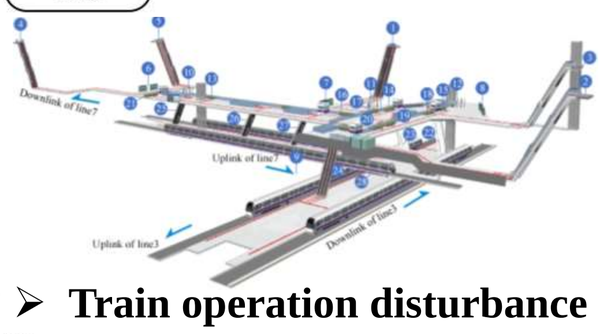


IMPLEMENTATION

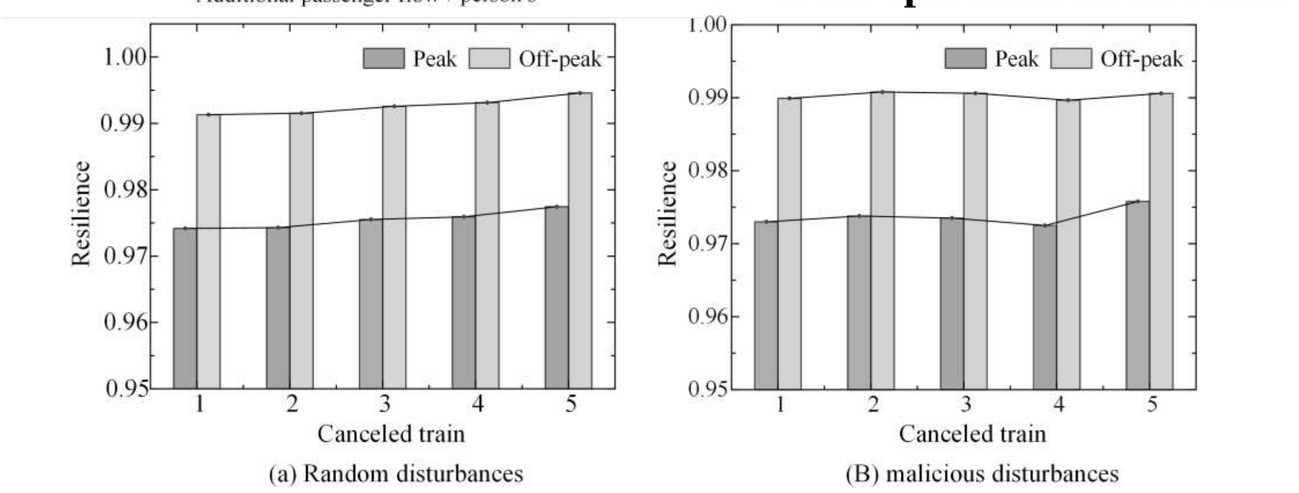
We take the Simaqiao Station of the Chengdu Metro as an example.

➢ **Passenger flow disturbance**

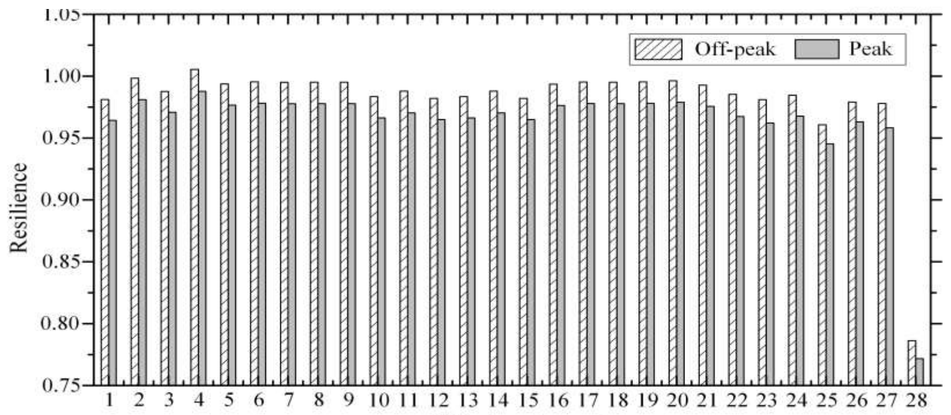




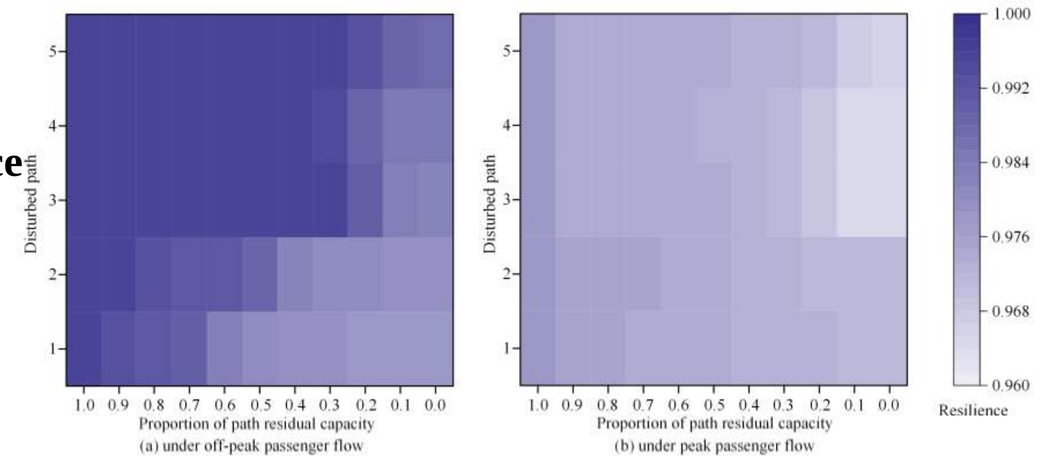
➢ **Train operation disturbance**



➢ **Facility and equipment disturbance**



➢ **Walking path disturbance**



CONCLUSION

For facilities and equipment disturbances, walking path disturbances, and train operation disturbances, the Simaqiao station can resist and recover without additional measures.

Based on the results, suggestions for improving station resilience are put forward including adding security inspection equipment, strengthening passenger flow guidance, ensuring train operation, etc.