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# A PH/PH(*n*)/*C*/*C* State-dependent Queuing Model for Metro Station Corridor Width Design

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## ABSTRACT

Metro station corridor width design considering demand fluctuation as well as the randomness and state-dependence of service time is an urgent concern and a complicated random planning issue. This paper confirms the accuracy of phase-type distribution (PH) fitting for passenger arrival intervals and service times with randomness and state-dependence in metro station corridors. A PH/PH(*n*)/*C*/*C* state-dependent queuing model is thus established by a finite level-dependent quasi-birth-death (QBD) process. The existing M/G(*n*)/*C*/*C*, M/G/1/*C*, and D/D/1/*C* models are proved to be special cases of the PH/PH(*n*)/*C*/*C* model through theoretical derivation and the precision of the proposed model is analyzed through simulation tests. The quantitative relationship between the level of service (LOS) and the corridor width is established based on the proposed model. A total of 81 experiments are designed to compare the calculations between the proposed model and the M/G(*n*)/*C*/*C*, M/G/1/*C*, and D/D/1/*C* models. Comparison results demonstrate that 1) the value of effective width of the PH/PH(*n*)/*C*/*C* queuing model is higher than those of the M/G(*n*)/*C*/*C*, M/G/1/*C*, and D/D/1/*C* models; 2) the real area occupied per person in the corridor of the PH/PH(*n*)/*C*/*C* queuing model is mostly proximate to the designed LOS, whereas those of the M/G(*n*)/*C*/*C*, M/G/1/*C*, and D/D/1/*C* models fail to meet the designed LOS; and 3) the performance measures of the PH/PH(*n*)/*C*/*C* queuing model enjoy high performance-width elasticity and are significantly improved compared with those of the M/G(*n*)/*C*/*C*, M/G/1/*C*, and D/D/1/*C* models.

## KEYWORDS

Facilities planning and design; Queuing; Metro station corridor; Coefficient of variation; State-dependence; Quasi-birth-death process

## 1. INTRODUCTION

### 1.1 Research Significance

The Existing Code for Design of Metro [1, 2] determines corridor width based on the given level of service (LOS), which is convenient for practical application. However, the code applies fixed-length distribution in the hypotheses of passenger arrival interval and service time (time for passing through the corridor), which neglect the randomness of passenger arrival interval (demand fluctuation) as well as the randomness and state-dependence of service time. Service time depends on the number of passengers (*n*), namely, system state, in the corridor; when system state *n* reaches the corridor capacity, it causes jamming in the corridor, and the service time becomes infinitely long. Thus, the designed corridor width cannot satisfy the required LOS and fluctuating demand. In several metropolises in China (e.g., Beijing and Shanghai), corridor service facilities at urban rail transit stations are always overloaded even during the off-peak period of passenger flow because of the demand fluctuation as well as the randomness and state-dependence of service time. (This situation is confirmed by the abundant experiments designed in Section 5). Therefore, considering demand fluctuation as well as the randomness and state-dependence of service time to establish the quantitative relationship between LOS and corridor width is an urgent concern.

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