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Balancing the baggage handling performance of a check-in area shared by multiple airlines

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ABSTRACT

Baggage handling systems (BHS) take up a significant portion of an airport's overall operation. In particular, an entryway BHS is an essential component as it facilitates a smooth transition for baggage flowing from the check-in area to the general BHS by reconstituting a dynamic baggage flow into a stable flow on a conveyor system. The main purpose of this research is to determine an appropriate workload balance for a BHS line being shared by multiple airlines. This is particularly relevant in the South Korean context, as imbalances have been observed in the BHS design for an extension at Gimhae International Airport. These imbalances lead to a lower customer satisfaction rates for that particular airline as well as a reduction in the level of service provided by the airport during peak hours. In this study, new window reservation control logic, a re-allocation algorithm using a merge configuration, is applied to the entryway BHS. This allows the system to efficiently control the baggage flow space from respective check-in counters so as to relieve conveyor bottleneck, an intrinsic problem leading to the imbalances. A simulation model is used to test the validity of the suggested algorithm, and to investigate the effects on the performance measures related to both the BHS and check-in area. The results indicate that this suggested algorithm reduces the imbalances for the airlines sharing the BHS collection conveyor, while maintaining overall BHS performance at an acceptable level. The relationships between the variable used in the algorithm and overall performance are discussed further.

1. Introduction

An airport baggage handling system (BHS) is one of the most complex airport operational systems. It is responsible for moving, controlling, screening, sorting and storing passenger baggage from the check-in area to the departure gates. Because the system is mainly composed of a series of conveyors that are connected as a whole system, a bottleneck in any part of the system could possibly affect the entire system. For this reason, an analysis of the system in the design phase has been emphasized to ensure system capacity under any circumstances by identifying the potential bottleneck area and assessing the deliverable capacity (de Neufville, 1994). If an effective design is not achieved, customer satisfaction rates decline due to delayed baggage or increased waiting times in passenger queues. In fact, these problems have become evident in numerous airports that are unable to handle baggage demands during peak operating hours.

With respect to potential bottlenecks in the BHS, check-in systems have often been identified as problem areas, particularly because several input conveyors merge into a collection conveyor (Le et al., 2012). A check-in system layout is shown in Fig. 1. It is identical to a merge configuration in a conveyor system. Regarding the conveyor system, an imbalance is inherent in the merge configuration caused by different blocking rates among the input conveyors. A blockage is a situation in which no more baggage can be conveyed because previous baggage items are stuck at the check-in conveyors. The chances of a blockage are affected by the baggage waiting times on the input conveyors. Moreover, baggage waiting times are determined by the distance from the upstream collection conveyor to the input conveyor. For instance, assuming that there are simultaneous arrivals on two input conveyors, the input having the shorter distance from the upstream collection conveyor has a shorter baggage waiting time since it takes priority when joining the collection conveyor.

Check-in system blockage problems have been a focal point for a study of the BHS at Gimhae International Airport in South Korea.

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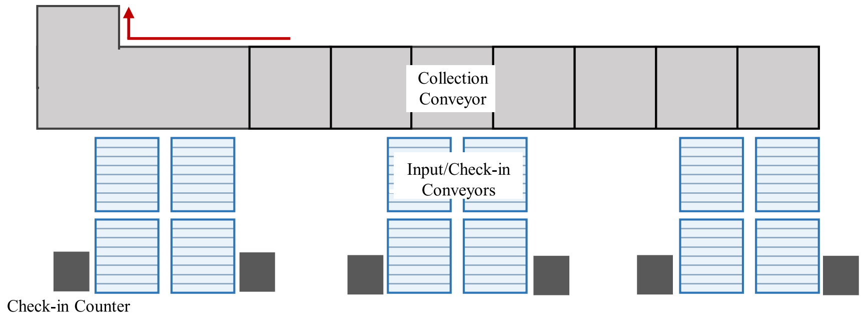

Fig. 1. BHS check-in system layout.

Although these problems are not the main causes of the aircraft delay or the BHS break down, it may lead to lower customers' satisfactions, imbalances among airlines, and a lower level of airport service. In our research, a BHS line is shared by multiple airlines that generate multiple queues, and the simulation model is tested for scenarios under peak hours. The results not only show input conveyor workload imbalances, but also subsequent waiting time imbalances in passenger queues. Because the downstream input conveyors have fewer insertion opportunities, i.e. there is a greater chance that blockages will occur, the service being provided at check-in is interrupted and passenger queue times consequently increase. In this way, a low level of service is offered at the airport due to the increased average and maximum passenger waiting times, both of which are primary performance measures.

Regarding the blockage problem, several solutions have been proposed, such as changing the physical layout or extending the system to increase capacity. However, these solutions have been limited in the design phase, and, more importantly, they suffer from increased costs with respect to both time and money. Moreover, extending the system would require more space in the check-in area, which could be thought of as a shortcoming. Another consideration is the control logic used in the merge configuration to deal with blockages. The first-in first-out (FIFO) based control logic is known as window reservation. This effectively controls the merge configuration by allocating a window, which is a logical space reserved for incoming baggage on a collection conveyor. Even though the window reservation system can solve input conveyor blockage problems, the imbalance problem among multiple queues and other blockage problems remain significant.

The current study proposes a new merge configuration control logic designed to relieve conveyor blockages. It helps to balance baggage waiting times as much as possible among input conveyors by re-allocating windows that have already been assigned. The suggested algorithm is tested on a simulation model in which a line is shared by multiple airlines that generate multiple queues in the check-in area. Performance is measured with respect to service quality among airlines and the level of service of the airport. Regarding airline service quality, the service levels and times in passenger queues are used as performance indices. Meanwhile, the maximum and the average passenger waiting times are checked in terms of the level of service of the airport. Throughput and baggage travel time are also considered with an integrated view of the BHS and check-in service.

This paper is organized as follows. In Section 2, the conveyor-based BHS process and the basic window reservation flow applied to the collection conveyor are described. The literature related to BHS and control logic are reviewed in this section. In Section 3, a detailed description of the problem with some examples is given. The BHS problem at Gimhae Airport is also discussed. In Section 4, the BHS layout used in the simulation model and the input data are described. In Section 5, the re-allocation algorithm is introduced with several simplifications. Then, the experiment results and findings are presented in Section 6. Finally, conclusions are drawn in the last section.

2. Background

2.1. Airport BHS in check-in area

An airport BHS is a series of conveyors that move baggage from a check-in area to a loading area, as shown in Fig. 2. The process begins when a passenger puts baggage on a check-in conveyor for weighing and labelling. Once the baggage is checked, it moves along the conveyors, passing an automatic tag reader for bag identification and x-ray machine for the security check. If no additional work is required, the baggage is then immediately sent to the carousel conveyor, the final stage of the BHS. On the other hand, if additional work such as manual tag reading or additional security checks is required, an inspection site is required with additional personnel. Since all of these processes, stakeholders, and equipment are highly interrelated as a single system, it is vital to evaluate the deliverable capacity for each component of the BHS and to identify potential bottlenecks.

Due to the variability and uncertainty inherent in BHS, simulations are widely used to evaluate system performance. Although several BHS analysis models have been suggested, including the meta-model offered by Khosravi et al. (2009) or the queueing model given by Jing et al. (1998), these models have thus lacked precision. In particular, they have not been able to predict BHS behavior during peak hours. For this reason, simulations are required to ensure accuracy.

Considering the BHS as a conveyor system, Hanta and Požival (2010) used a simulation model to determine deliverable capacity. They also pointed out that a bottleneck would occur when a number of customers arrived at the same time, or when staff numbers were insufficient. Robinson (1969) investigated baggage claim area layouts in order to minimize costs. His approach focused on grouping BHS and passengers as single systems. (The current study also takes this approach.) In the aforementioned literature, passenger delay costs are estimated with the assumption that such delays result in increases in person-hours. However, their solution centers on designing systems with more equipment or resources. On the contrary, the present study endeavors to achieve efficiency without adding resources.

Lin and Huang (2015) offered a robust near-optimal time window setting, which is the time allowed for early baggage to stay in the buffer zone. They used a simulation model as a BHS evaluation tool. A number of scenarios under different control settings were investigated to avoid bottlenecks in the confluence area. They also found that a trade-off between congestion and performance indices