Background Reading

Efforts to enhance airport efficiency have become paramount in modern aviation management, as highlighted by research such as the Simulation Evaluation Model of Airport Airspace and Ground Operational Efficiency. This study, presented at the International Conference on Applied Mathematics, Modeling, and Simulation (AMMS 2017), underscores the multifaceted nature of evaluating operational effectiveness in large airports. By employing the Analytic Hierarchy Process (AHP), the research identifies critical factors affecting both airspace and ground operations, including arrival air delays, departure ground delays, and the number of arriving and departing routes and flights. The adoption of the index scale method for weighting these factors demonstrates a nuanced approach to ensuring the preservation of order, consistency, and uniformity in evaluation. However, the study also highlights the complexity of the task at hand, suggesting that future analyses could benefit from in-depth exploration through specific airport simulation cases. This research reflects a broader trend within the aviation industry, where stakeholders continually seek innovative solutions to optimize airport performance and enhance overall efficiency.

In Airport COO, incorporating formulas for Flow Equilibrium at entry/exit points and Runway Usage Equilibrium is pivotal for accurate airport simulation. The Flow Equilibrium formula assesses traffic balance, identifying congestion and inefficiencies. Similarly, the Runway Usage Equilibrium formula optimizes multiple runway utilization by quantifying departure/arrival rate standard deviations. These formulas, rooted in research like the Simulation Evaluation Model of Airport Airspace and Ground Operational Efficiency, offer a scientific basis for enhancing Airport COO. They enable more efficient decision-making and improved operational performance in real-world airport environments.

The Study paper presented 2 important formulae

1. Flow Equilibrium of Entry and Exit Point

Assuming that there are n_i^P entry and exit points in Scheme i, the flight flow rate of each entry and exit point is $S^P(i,j)$, $i = 1,\cdots,n$, $j = 1,\cdots,n_i^P$. The standard deviation $A_4^{PS}(i)$ of the flight flow rate of the entry and exit points in Scheme i is:

$$A_4^{PS}(i) = \sqrt{\frac{\sum_{j=1}^{n_i^P}[S^P(i,j) - S^P(i)]^2}{n_i^P - 1}} \qquad (4)$$

2. Equilibrium of Runway Usage

There are usually multiple runways in large airports, and the usage of those runways varies. Assuming that Scheme i planned n_i^R runways with the D/A flights rate of each runway accounted for $S^R(i,k)$, $i=1,\cdots,n$, $k=1,\cdots,n_i^R$. The standard deviation $G_2^{RS}(i)$ of the D/A flights rate in Scheme i is:

$$G_2^{RS}(i)=\sqrt{\frac{\sum_{k=1}^{n_i^R}[S^R(i,k)-S^R(i)]^2}{n_i^R-1}} \tag{8}$$

The research paper titled "Design of airport security screening using queueing theory augmented with particle swarm optimisation" sheds light on the critical importance of airport security screening in ensuring aviation safety and passenger well-being. The study presents a novel hybrid model, QT-PSO, which combines queueing theory with particle swarm optimisation to predict passengers' average waiting time more accurately. By incorporating variations in service time and introducing a new parameter, "walking time," the QT-PSO model enhances prediction accuracy, outperforming existing methods such as M/M/S and regression models. However, it is noted that the proposed model exhibits limitations when the number of servers is less than 3, suggesting a need for further research. The experiments conducted using real data from Sydney International Airport demonstrate the effectiveness of the QT-PSO model in closely simulating actual waiting times. Notably, the model's ability to anticipate optimal server numbers offers valuable insights for security managers, enabling timely adjustments to accommodate varying passenger volumes. Overall, the findings underscore the significance of integrating advanced mathematical models like QT-PSO into airport simulations to optimize security screening processes and enhance operational efficiency.

We use Lindley's equation which n takes into consideration the time between the passenger's arrival during the service time and equation for average waiting and response time for setting up our simulation.

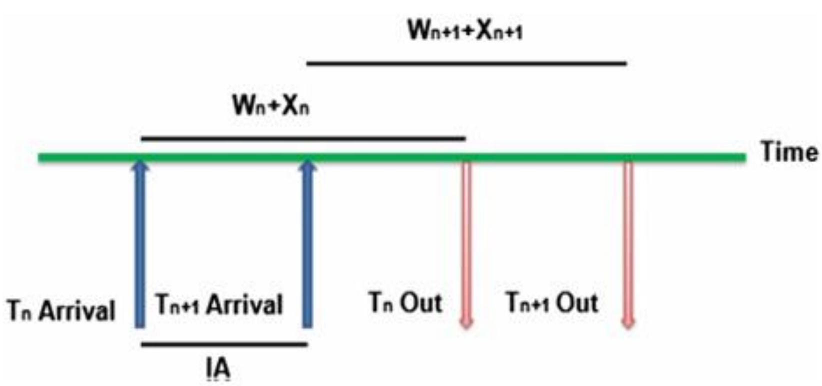

Fig. 1 Lindley process principle

$$C(s,\alpha) = \frac{\frac{\alpha^s}{s!(1-\frac{\alpha}{s})}}{\sum_{k=0}^{s-1} \frac{\alpha^k}{k!} + \frac{\alpha^s}{s!(1-\frac{\alpha}{s})}} \tag{1}$$

The average waiting and response (sojourn) times, respectively, are:

$$E(W) = \frac{C(s,\alpha) * \mu}{(1-\rho)S} \tag{2}$$

$$E(R) = E(W) + \mu = \frac{C(s,\alpha) * \mu}{(1-\rho)S} + \mu \tag{3}$$

where C(s, α) is the fraction of time servers assumed to be busy, S is the number of servers, ρ is the utilisation or an average number of busy servers and α is the offered load or the number of passengers to arrive at the security area.

Citations

Li, X., Chen, X. Q., & Wei, D. (2018). *Comprehensive evaluation of airspace and ground operation simulation in Large-Scale Airport*. https://www.semanticscholar.org/paper/Comprehensive-Evaluation-of-Airspace-and-Ground-in-Li-Chen/e25613f2ddf77ef164c892c9933dd5b355d06982

Naji, M., Braytee, A., Al-Ani, A., Anaissi, A., Goyal, M., & Kennedy, P. J. (2020). Design of airport security screening using queueing theory augmented with particle swarm optimisation. *Service Oriented Computing and Applications*, *14*(2), 119–133. https://doi.org/10.1007/s11761-020-00291-0