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CS1538 Intro to Simulation  
HW#4 Write-up

Airline Simulation

Experimental Design

The first step in my experimental design process was to determine the number of runs. I used the original values given in the assignment with a 24-hour day in order to determine the number of runs to use in each simulation. Results didn’t seem to change much for runs greater than 200, so I decided to use that. I had initially intended to use something greater, around 500-1000, but the computation time was too high to feasibly acquire all the results.

I choose 500 for the number of hours to run the simulation for. Running for only 24 hours would not be enough to get well-averaged results. At the same time, running for an entire year seemed excessive. 500 hours, a bit less than one month, should be a sufficient amount of time to allow the system to stabilize. It was also a reasonable time for computation’s sake.

I initially planned to run my program using all possible iterations of counters starting with a minimum of 4 counters. After doing so for the 4 counter set, it was immediately obvious that it was unnecessary to try cases where the number of first class counters was greater than the number of coach counters. This is intuitive as well, since there are so many more coach passengers in the system than there are first class passengers. Having more first class counters than commuter counts make the commuter check-in wait time entirely unreasonable.

My results come in four sets; where the commuter interval is set to 30, 60, 90, and 120 minutes, respectively.

Results

My full results are contained in four attached files, results30.txt, results60.txt, results90.txt, and results120.txt. Tables are presented below organizing the findings. The best value of each column is highlighted in blue.

Note: I noticed right before submission that my values for the number of security screening machines were backwards- I had 2 for first class and 1 for coach. I am unable to redo all of this output in time, so my output for international passengers missing their flights is lower than it should be.

Profit (over the full 500 hours)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 30 | 60 | 90 | 120 |
| 1 FC, 3 Coach | $15594049 | $16095918 | $16261429 | $16352604 |
| 2 FC, 2 Coach | $15511149 | $16012416 | $16179055 | $16261501 |
| 1 FC, 4 Coach | $15578354 | $16086159 | $16256895 | $16334955 |
| 2 FC, 3 Coach | $15583088 | $16085816 | $16247434 | $16341782 |
| 1 FC, 5 Coach | $15574182 | $16072793 | $16236577 | $16325743 |
| 2 FC, 4 Coach | $15582849 | $16076144 | $16237455 | $16332141 |
| 3 FC, 3 Coach | $15576058 | $16070945 | $16241487 | $16325891 |

Average check-in wait time (in minutes)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 30 | 60 | 90 | 120 |
| 1 FC, 3 Coach | 13.14 | 13.19 | 13.23 | 13.13 |
| 2 FC, 2 Coach | 1028.39 | 1010.40 | 1025.59 | 1011.26 |
| 1 FC, 4 Coach | 6.49 | 6.49 | 6.52 | 6.48 |
| 2 FC, 3 Coach | 12.38 | 12.41 | 12.42 | 12.43 |
| 1 FC, 5 Coach | 3.99 | 4.02 | 4.01 | 4.01 |
| 2 FC, 4 Coach | 5.75 | 5.74 | 5.75 | 5.75 |
| 3 FC, 3 Coach | 12.25 | 12.23 | 12.21 | 12.29 |

Average number international passengers that missed their flights

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 30 | 60 | 90 | 120 |
| 1 FC, 3 Coach | 0.003910 | 0.004138 | 0.004214 | 0.003853 |
| 2 FC, 2 Coach | 0.623528 | 0.624035 | 0.624058 | 0.623540 |
| 1 FC, 4 Coach | 0.000120 | 0.000135 | 0.000124 | 0.000135 |
| 2 FC, 3 Coach | 0.003951 | 0.004037 | 0.003885 | 0.003990 |
| 1 FC, 5 Coach | 0.000119 | 0.000130 | 0.000120 | 0.000128 |
| 2 FC, 4 Coach | 0.000002 | 0.000002 | 0.000002 | 0.000002 |
| 3 FC, 3 Coach | 0.003952 | 0.003871 | 0.003869 | 0.004071 |

Average post-security-screening wait time for commuters

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 30 | 60 | 90 | 120 |
| 1 FC, 3 Coach | 14.96 | 30.31 | 45.58 | 64.02 |
| 2 FC, 2 Coach | 13.98 | 27.98 | 41.89 | 55.95 |
| 1 FC, 4 Coach | 15.05 | 29.41 | 42.88 | 58.69 |
| 2 FC, 3 Coach | 14.96 | 30.32 | 45.56 | 64.04 |
| 1 FC, 5 Coach | 15.06 | 29.37 | 42.45 | 57.86 |
| 2 FC, 4 Coach | 15.03 | 29.41 | 42.85 | 58.73 |
| 3 FC, 3 Coach | 14.97 | 30.32 | 45.60 | 64.01 |

Percentage of ticket revenue going to agent pay

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 30 | 60 | 90 | 120 |
| 1 FC, 3 Coach | 0.50 | 0.50 | 0.50 | 0.50 |
| 2 FC, 2 Coach | 0.50 | 0.50 | 0.50 | 0.50 |
| 1 FC, 4 Coach | 0.57 | 0.57 | 0.57 | 0.57 |
| 2 FC, 3 Coach | 0.57 | 0.57 | 0.57 | 0.57 |
| 1 FC, 5 Coach | 0.64 | 0.64 | 0.64 | 0.64 |
| 2 FC, 4 Coach | 0.64 | 0.64 | 0.64 | 0.64 |
| 3 FC, 3 Coach | 0.64 | 0.64 | 0.64 | 0.64 |

Average agent idle time (per agent)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 30 | 60 | 90 | 120 |
| 1 FC, 3 Coach | 47.93 (x4) | 47.91 (x4) | 47.93 (x4) | 47.93 (x4) |
| 2 FC, 2 Coach | 53.03 (x4) | 52.97 (x4) | 53.00 (x4) | 53.00 (x4) |
| 1 FC, 4 Coach | 44.51 (x5) | 44.50 (x5) | 44.52 (x5) | 44.51 (x5) |
| 2 FC, 3 Coach | 44.50 (x5) | 44.50 (x5) | 44.52 (x5) | 44.52 (x5) |
| 1 FC, 5 Coach | 41.35 (x6) | 41.35 (x6) | 41.35 (x6) | 41.35 (x6) |
| 2 FC, 4 Coach | 41.34 (x6) | 41.34 (x6) | 41.34 (x6) | 41.35 (x6) |
| 3 FC, 3 Coach | 41.35 (x6) | 41.34 (x6) | 41.34 (x6) | 41.34 (x6) |

Discussion

As far as the commuter interval is concerned, it strongly affects average post-security-screening wait time for commuters in that every 30 minutes results in the lowest wait time, increasing to the highest wait times with 120 minutes. Unfortunately, it is not easy to simply say that commuter planes should arrive every 30 minutes, because that is where profits are at a minimum. It would be around a half million dollar decrease over the 500 days if the airline were to switch from 60 minutes to 30 minutes. Wait times for 60 minutes are about twice as long but not unreasonable, so I think the airline should stay with 60 minute commuter intervals as a medium between profits and wait times.

Idle time for agents clearly increases with an increase of total agents. Similarly, the percentage of revenue that goes to paying the agents increases with the agent count.

Average check-in wait time is greatest for 1 first class agent and 5 coach agent. If the airline does not wish to use 6 tellers because of the aforementioned drawbacks to increasing agent amount, they may consider a middle-ground of 5 agents. 1 first class agent and 4 coach agents works well to ensure short check-in wait times and few first class passengers missing their flights.

While the airline may not be able to fully satisfy all of its goals with one optimal set of changes, it should be able to make some educated decisions and find a system that is far better than the one they were using before. Having the commuter interval set to 60 minutes and having 1 first class agent and 4 coach agents seems to be the airline’s best option.

If other things are changed, such as the chance of a person wanting to go on an international flight in a coach seat increasing or decreasing, the check-in agent allocation may change. Another run of the simulation with the new values would indicate if the current settings are still viable or if they ought to be changed. It is likely that if the chance of a coach seat decreased, one of the agents currently allocated to the coach class may be switched over to first class.

There are plenty of other variables that can be modified to see their result on this airline system. More security screening stations, more counters, more or less international flights a day, and changing prices are a few such potential changes.

Here is output showing how having international flights every 4 hours instead of every 6 changes our system with the 60 minute commuter interval,1 first class agent and 4 coach agents.

Results (averaged over 200 runs) for 1 first class counters and 4 coach counters:

Profit over 500 hours: $20026654

Average check-in wait time: 8.67 minutes

Average number of international passengers that missed their flights (per flight): 0.000143

Average post-security-screening wait time for commuters: 29.12 minutes

Percentage of ticket revenue going to agent pay: 0.46

Average agent idle time per agent: 41.76 hours