Finding the Optimal Number of Washers and Dryers in a Dormitory: A Simulation-Based Approach

John Oleszkiewicz

February 26, 2004

Abstract

College laundry rooms typically have an equal number of washers and dryers despite a marked difference in service time between the two types of machines. This configuration of machines introduces unnecessary delay to the laundry process due to the difference in service times. I have created a simulator to measure the severity of this problem and determine an optimal laundry room configuration. In this paper, I describe this simulator and use it to model the laundry room at Owen Graduate Hall at Michigan State University. I then describe the results it provides.

1 Introduction

Laundry rooms are a crucial aspect of college life. Space constraints in dormitories force the use of communal laundry rooms. Because laundry rooms are a shared, limited resource, it is inevitable there will contention for the resource. This contention will result in delays caused by waiting. It is in the college's best interest to minimize delays and keep student turnover high. High throughput increases both student satisfaction and money received by machines.

Inexplicably, many college laundry rooms introduce an inefficiency to the system and cause unnecessary delay. The act of doing laundry is a two-stage process. The first stage is washing, the second is drying. The drying stage takes approximately twice the amount of time as washing. It would be logical, then, to have more dryers in a laundry room than washers to accommodate this higher service time. This is rarely the case. In fact, the number of washers is typically equal to or greater than the number of dryers.

This arrangement presents a problem. If the laundry room is in heavy use, the number of available dryers will drop more quickly than available washers. This results in students washing their clothes but then waiting for dryers to become available. This backlog is a needless detriment to student satisfaction and could be corrected by a altered configuration of washers and dryers.

I have created a laundry room simulator to investigate this problem. In this paper, I will first describe the simulator and the models used to simulate machine and student behavior. Second, I will describe the parameters of the simulation that demonstrates the problem and of the simulations that explore other possible room configurations. Third, I will report results of the defined simulations. Fourth, I will draw conclusions based on these results.

2 Methodology

2.1 Simulator Models

The simulator assumes a single laundry room filled with washers and dryers. This room services a set population of students. It is assumed all students typically do their laundry within a set period of time (set as a parameter). The size of the student population and the time between laundry trips is used to generate an average arrival time of students. This average arrival time is used by an exponential distribution to determine when the next student will arrive at the laundry room.

A load of laundry is defined as how many clothes may be fit into a single washer or dryer. The average number of loads (and the standard deviation) a student has at each laundry event is set as a parameter. The minimum number of loads a student may have is one. The maximum number of loads a student may have is limited by the number of machines in the room. If the student has more loads than physically present machines, it is assumed the student will compress multiple loads into an acceptable number of loads.

Once a student arrives, it assumed that a first-in-first-out queue is established for both washers and dryers. No preemption is allowed. If there are enough idle machines available to accommodate the first student in line's loads, then those machines are immediately put into use. If there are not enough idle machines are available, the first student will wait until enough machines become available.

Machine service times are constants set as parameters. It is assumed that after a machine is done servicing a load, additional time is spent by the student unloading the laundry from the machine. The amount of time the student takes to do this will vary according to a normal distribution. The average and standard deviation of this distribution are set as parameters to the simulation. The minimum amount of time spent on this task is zero minutes.

It is assumed that machines never go out of service.

2.2 Base Simulation Setup

I simulate the configuration of Owen Graduate Hall at Michigan State University. Owen Graduate Hall houses approximately 850 students. Owen has one laundry room with sixteen washers and sixteen dryers. Washers have a service time of 26 minutes. Dryers have a service time of 60 minutes.

Students are assumed to need to do laundry every two weeks on average. It is assumed that students take an average of two loads of laundry on each trip with a standard deviation of 2. Based on the population size and frequency of laundry events, one student should arrive at approximately every 40 minutes.

It assumed that it takes a student five minutes to unload their laundry from machines, on average (with a standard deviation of two minutes). With this information, we can calculate that, assuming no waiting time, it will take a student 96 minutes to do their laundry.

The simulation is run for one year of simulated time and with a random number seed of 1.

2.3 Other Simulations

Other simulations will change the configuration of the Owen laundry room slightly. The only parameters that will be changed are the number of washers and dryers. All other parameters will retain the same values.

3 Results

The simulator provides multiple metrics but this section will focus on the most relevant: average student residence time. Residence time measures how long, on average, it took a student to do their laundry from the time the student enters the room until the time he leaves the room.

Running the base simulation, the average residence time is 97.12 minutes. This is impressive, as it is only 1.12 minutes away from the optimal time. It will be informative to observe how residence time changes as the number of machines change.

I add and subtract washer and dryer pairs to examine how additional machines may affect residence times. It takes subtracting five pairs before residence times start to become substantial. With 11 washers and 11 dryers, residence time rises to 106.49, or 10.49 minutes above the optimal time. Adding five pairs brings residence time closer to optimal - 96.21 minutes. The overall effect of adding pairs is relatively low.

What is more interesting is the impact of specific types of machines on the residence times. If we change the number of washers in the room, the residence time is virtually unchanged - with a

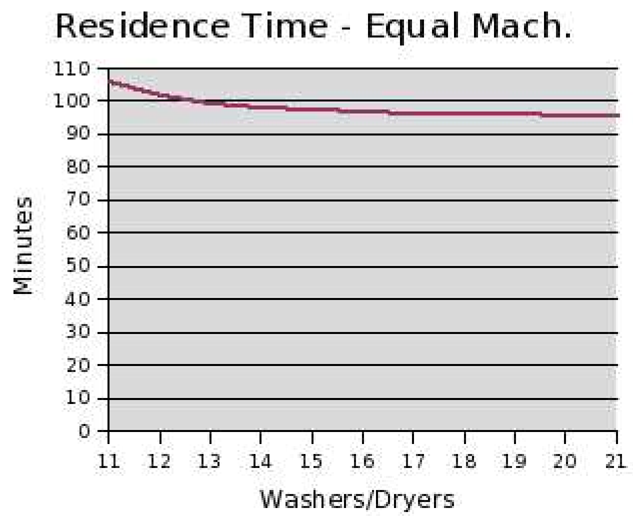

Figure 1: Washers and dryers added and subtracted in equal amounts

maximum of 97.31 minutes and a minimum of 97.12 minutes. However, if we remove dryers from the system, the change in residence time closely matches the change in residence time experience when washer/dryer pairs were removed.

If we assume that the Owen laundry room only has room for 36 machines, then we can adjust the types of machines to find the optimal configuration. Twelve washers and twenty dryers is the optimal configuration - with 96.43 minutes of residence time. Thirteen washers and nineteen dryers yields a slightly higher residence time of 96.45 minutes. Eleven washers and twenty-one dryers yields a higher residence time of 96.54 minutes.

4 Conclusions

The simulations confirm that the dryers in a laundry room are a bottleneck resource and an equal number of washers and dryers in a laundry room is not an optimal configuration. It appears that Owen Graduate Hall's laundry gets good performance simply by having a large number of both washers and dryers. However, by changing the balance of washers and dryers we can reduce response time to close to optimal levels.

It appears that the optimal ratio of washers to dryers is approximately 2:3. In our simulation, it was precisely 3:5. Future laundry room installations should adopt this ratio and abandon the 1:1 washer/dryer ratio.

5 Future Work

This work is only preliminary. The most obvious work that needs to be done is to rigorously observe student behavior and determine is it truly conforms to the models and parameters used in the simulator. Re-running the described experiments with different random number seeds and

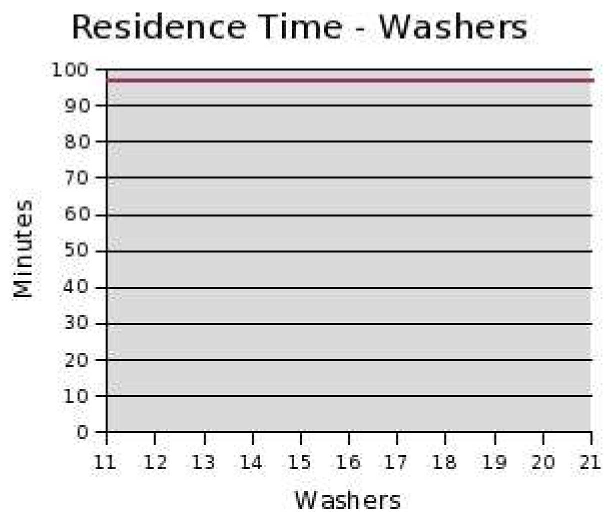

Figure 2: Washers added and subtracted, dryers held constant at 16

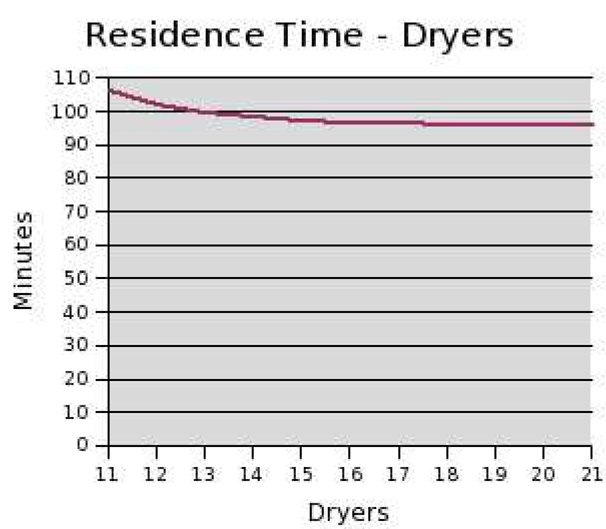

Figure 3: Dryers added and subtracted, washers held constant at 16

Figure 4: Washers and dryers added and subtracted to always total 32

averaging results would lend statistical credibility to the results.

For the simulations described in this paper, many aspects of college laundry rooms were left unexplored. Laundrysim allows many different configurations to be simulated and many different setups could be simulated in the future.