TITLE: HW #9 Assignment
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DATE SUBMITTED: 13-MAR-19

LEGEND

- HOMEWORK ASSIGNMENT
- PROGRAM CODE
- ANALYSIS & SOLUTIONS
- GRAPHS & PLOTTING

Question 12.1
Describe a situation or problem from your job, everyday life, current events, etc., for which a design of experiments approach would be appropriate.

In my role at my company, our team works with an exorbitant amount of both structured and non-structured data sets. Specifically speaking, the major initiative our team is currently addressing involve addressing HR related issues which span multiple functionalities encompassing employee performance, career progression, and retention rates. The team has built forecasting models based on the experimental design algorithms, specifically Binomial & Poisson functions, which help optimize forecasting initiatives involving the following critical questions posed by the senior management team:

1. The likelihood of top performing employees departing the company after getting passed over for a promotion and/or salary increase (Binomial)
2. The time required to backfill his/her position with a new hire (Poisson)
3. The time required to train the new employee (Geometric)
4. The employment time needed to recoup 'Return on Investment' costs as part of the onboarding and training process (Geometric).

As a result of the proposed hypothetical questions stated above, our team regularly implements design-oriented experiments in order to help optimize existing forecasting models to better provide leadership teams improved accuracy in their existing data sets in order to improve upon their existing decision making procedures.

Question 12.2
To determine the value of 10 different yes/no features to the market value of a house (large yard, solar roof, etc.), a real estate agent plans to survey 50 potential buyers, showing a fictitious house with different combinations of features. To reduce the survey size, the agent wants to show just 16 fictitious houses . Use R's `FrF2` function (in the `FrF2` package) to find a fractional factorial design for this experiment: what set of features should each of the 16 fictitious houses have?

As directed by the Ritwik's officer hours, I modified the code depicted during the lesson in order to run the program on my local computer. Figure 12.2.1 depicts the output for the fractional factorial design based on the two models.

My proposed 10 variables for this model include the following:

1. Garage
2. Fenced Backyard
3. Centralized air/heat
4. Sprinkler systems
5. 2000 or newer
6. Home Security
7. HOA
8. Public Parking
9. Basement
10. Handicap Capable

//Fig. 12.2.1

```
> first <- FrF2(16,10)
> second <- FrF2(16,10)
>
> first
    A  B  C  D  E  F  G  H  J  K
1   1 -1 -1  1 -1 -1  1  1  1  1
2   1  1 -1 -1  1 -1 -1 -1  1  1
3  -1 -1  1 -1  1 -1 -1  1  1 -1
4   1  1  1  1  1  1  1  1  1  1
5  -1 -1  1  1  1 -1 -1 -1 -1  1
6   1 -1  1  1 -1  1 -1  1 -1 -1
7   1  1 -1  1  1 -1 -1  1 -1 -1
8  -1 -1 -1  1  1  1  1 -1  1 -1
9  -1  1  1 -1 -1 -1  1  1 -1  1
10  1  1  1 -1  1  1  1 -1 -1 -1
11  1 -1  1 -1 -1  1 -1 -1  1  1
12 -1  1  1  1 -1 -1  1 -1  1 -1
13  1 -1 -1 -1 -1 -1  1 -1 -1 -1
14 -1 -1 -1 -1  1  1  1  1 -1  1
15 -1  1 -1  1 -1  1 -1 -1 -1  1
16 -1  1 -1 -1 -1  1 -1  1  1 -1
class=design, type= FrF2
> second
    A  B  C  D  E  F  G  H  J  K
1  -1 -1 -1  1  1  1  1 -1  1 -1
2   1  1  1  1  1  1  1  1  1  1
3   1 -1  1  1 -1  1 -1  1 -1 -1
4  -1  1  1  1 -1 -1  1 -1  1 -1
5   1  1  1 -1  1  1  1 -1 -1 -1
6   1  1 -1 -1  1 -1 -1 -1  1  1
7   1 -1 -1 -1 -1 -1  1 -1 -1 -1
8   1  1 -1  1  1 -1 -1  1 -1 -1
9  -1  1 -1  1 -1  1 -1 -1 -1  1
10  1 -1  1 -1 -1  1 -1 -1  1  1
11 -1 -1  1 -1  1 -1 -1  1  1 -1
12 -1  1  1 -1 -1 -1  1  1 -1  1
13 -1 -1 -1 -1  1  1  1  1 -1  1
14 -1  1 -1 -1 -1  1 -1  1  1 -1
15  1 -1 -1  1 -1 -1  1  1  1  1
16 -1 -1  1  1  1 -1 -1 -1 -1  1
class=design, type= FrF2
>
```

// Fig. 12.2.2

```
> first
   Garage Fenced Backyard Centralized air/heat Sprinkler systems 2000 or newer Home Security HOA Public Parking Basement
1       1              -1                   -1                 1           -1            -1   1              1        1
2       1               1                   -1                -1            1            -1  -1             -1        1
3      -1              -1                    1                -1            1            -1  -1              1        1
4       1               1                    1                 1            1             1   1              1        1
5      -1              -1                    1                 1            1            -1  -1             -1       -1
6       1              -1                    1                 1           -1             1  -1              1       -1
7       1               1                   -1                 1            1            -1  -1              1       -1
8      -1              -1                   -1                 1            1             1   1             -1        1
9      -1               1                    1                -1           -1            -1   1              1       -1
10      1               1                    1                -1            1             1   1             -1       -1
11      1              -1                    1                -1           -1             1  -1             -1        1
12     -1               1                    1                 1           -1            -1   1             -1        1
13      1              -1                   -1                -1           -1            -1   1             -1       -1
14     -1              -1                   -1                -1            1             1   1              1       -1
15     -1               1                   -1                 1           -1             1  -1             -1       -1
16     -1               1                   -1                -1           -1             1  -1              1        1
   Handicap Capable
1                 1
2                 1
3                -1
4                 1
5                 1
6                -1
7                -1
8                -1
9                 1
10               -1
11                1
12               -1
13               -1
14                1
15                1
16               -1
```

/* ---*/

```
# Filename: HW# 9 - Benitez P.
# Question: 12.2
# Author: Patrick C. Benitez
# Date created: 10-MAR-19
# Date updated: 10-MAR-19

#install.packages("FrF2")
#install.packages("plyr")

set.seed(23)
library(FrF2)
library(plyr)
rm(list = ls())

first <- FrF2(16,10)
first <- rename(first,c("A"="Garage",
                "B"="Fenced Backyard",
                "C"="Centralized air/heat",
                "D"="Sprinkler systems",
                "E"="2000 or newer",
                "F"="Home Security",
```

```
                    "G"="HOA",
                    "H"="Public Parking",
                    "J"="Basement",
                    "K"="Handicap Capable"))
second <- FrF2(16,10)
second <-rename(second,c("A"="Garage",
          "B"="Fenced Backyard",
          "C"="Centralized air/heat",
          "D"="Sprinkler systems",
          "E"="2000 or newer",
          "F"="Home Security",
          "G"="HOA",
          "H"="Public Parking",
          "J"="Basement",
          "K"="Handicap Capable"))

first
second
```

Question 13.1
For each of the following distributions, give an example of data that you would expect to follow this distribution (besides the examples already discussed in class).

a. **Binomial**
    a. The probability of an Army Soldier passing an Army Physical Fitness Test (APFT)
    b. The probability of a active duty military service member passing a urinalysis drug test after April 20th.
    c. The probability of a military veteran passing ISYE 6501 with a grade of "B" or better
b. **Geometric**
    a. Medical professionals testing a five (5) x new drugs which aims to provide reduce and mitigate the spread of the HIV virus; probability of success is assessed for a single patient is 0.001. Testing occurs until the first patient is identified as a 'success' for testing purposes
    b. A scaffolding manufacturing company which creates thousands of miscellaneous scaffold parts for buyers; geometric distribution would help identify the assessed time before the first assembly line point of failure during the manufacturing process.
    c. The probability of two TCP/IP entities (sender and receiver) sending packets of Youtube video clips before there is a network error
c. **Poisson**
    a. An Army platoon is designated to conduct rifle marksmanship (qualifying) activities for a specific day. The probability of all 25 Soldiers qualifying is 70%. We can use the Poisson equation to determine the probability of at least 90% of all Soldiers qualifying on their assigned weapon
    b. Nike is releasing a limited release run of a highly anticipated collaboration sneaker. The mean for the average length of personnel waiting in line prior to the 10am release date is 600 personnel. We can utilize the Poisson equation to determine the possibility of less than 100 personnel waiting in line before the 10am store opening.

   c. Poisson calculation can be utilized to determine the amount of people moving into a specific city, given the 12-month running average of new local citizens within a geographic area. For example, the Atlanta metropolitan area is gaining 7,000 new residents per month. We can use the Poisson equation to determine the probability QTR 3 months of Fiscal Year 2019 will not exceed 5,000 new residents

d. **Exponential**
   a. An Army Jumpmaster is responsible for loading as many as 100 paratroopers in an airplane. He is required to push out a jumper every 1.5 seconds in order to ensure all jumpers safely land in a pre-designated drop zone (DZ). We can utilize the exponential equation to determine the probability it will take over 3 seconds to push out a paratrooper from the airplane door
   b. An Army recruiter is expected to meet with over 50 high school recruits during peak times within the yearly recruiting season at a regional job conference. The average interview time is 10 minutes per each new recruit. We can utilize the exponential equation to determine the probability he will encounter an interview lasting more than 20 minutes.

e. **Weibull**
   a. We can utilize the 1-parameter Weibull to determine the expected lifetime of newly manufactured scaffold equipment once released to the regional branch team for rental. Expected lifetime use before component breakdown is assessed as part of the parameter for this equation.
   b. Car warranties for used cars (i.e Carmax) would provide insight information within a Weibull distribution. Two variables, sales data and warranty returns, would fit within a 2-parameter Weibull distribution model in order to determine the point of failure of used cars once sold by the car agency.

Question 13.2

In this problem you, can simulate a simplified airport security system at a busy airport. Passengers arrive according to a Poisson distribution with λ_1 = 5 per minute (i.e., mean interarrival rate ⍰$_1$ = 0.2 minutes) to the ID/boarding-pass check queue, where there are several servers who each have exponential service time with mean rate ⍰$_2$ = 0.75 minutes. [Hint: model them as one block that has more than one resource.] After that, the passengers are assigned to the shortest of the several personal-check queues, where they go through the personal scanner (time is uniformly distributed between 0.5 minutes and 1 minute).

Use the Arena software (PC users) or Python with SimPy (PC or Mac users) to build a simulation of the system, and then vary the number of ID/boarding-pass checkers and personal-check queues to determine how many are needed to keep average wait times below 15 minutes. If you're using SimPy or if you have access to a non-student version of Arena, you can use λ_1 = 50 to simulate a busier airport.]

As a Mac user I opted to utilize the Arena software course of action as part of the 13.2 homework problem. As depicted in Jeannie's Monday's office hours, I followed the step-by-step creation process and built my model until I completed a fully executed run with no errors. My process diagram is depicted in FIG. 13.2.1.

// Fig. 13.2.1

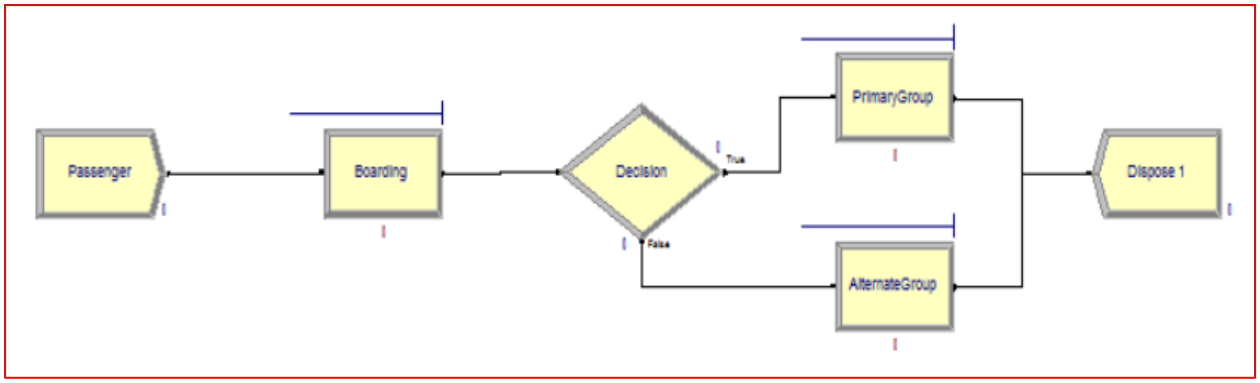

FIG 13.2.2 depicts the corresponding output for the base model, in which the 'Boarding,' 'Primary,' and 'Alternate' processes possess only a single (1) x resource as part of the initial trial run (i.e. 1x boarding agent, 1x scanner in the Primary, 1x scanner in Alternate). Based on the KPI reporting data, (Test Run #1.pdf), the initial model with the base variables already exceeded the proposed 15-min time limit requirement as part of this assignment. Both the boarding queue (.0003109 hr / 1.08 seconds) and scanner group queue (0.00019017 hr / 0.68 seconds) times far surpassed any waiting times which ultimately relegated the 'AlternateGroup' scanners as irrelevant during the passenger check in process.

// Fig. 13.2.2: Initial Run #1 w/ 1x Boarding Agent, 2x total scanners (one resource per scanner)

Values Across All Replications

Unnamed Project

Replications: 6 Time Units: Hours

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Boarding.Queue	0.00031009	0.00	0.00010670	0.00041738	0.00	0.04638062
PrimaryGroup.Queue	0.00019017	0.00	0.00013857	0.00031291	0.00	0.01516466

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
AlternateGroup.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Boarding.Queue	0.00365802	0.00	0.00134269	0.00494153	0.00	1.0000
PrimaryGroup.Queue	0.00227052	0.00	0.00162825	0.00382016	0.00	1.0000

Upon completion of the initial run with no errors I then preceded to modify the associated resource variables to include 'Boarding' and 'PrimaryGroup' and 'AlternateGroup' identifiers. I changed the 'Boarding' agent resource value from '1' to '3.' In addition, I initialized two (2) x new resources scanners within each of the 'PrimaryGroup' and 'AlternateGroup' in order to alleviate system queueing during the course of the process flow. As expected, the new changes to the model **did not** improve upon the base model's existing KPI values. Both the 'Boarding Queue' and 'Scanner Processing' queue times maintained the same interval values as part of passenger processing activities.

// Fig. 13.2.3: Test Run #1 w/ 3x Boarding Agents for checks, 4x total scanners (two in each group)

Values Across All Replications

Unnamed Project

Replications: 6   Time Units: Hours

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Boarding.Queue	0.00031009	0.00	0.00010670	0.00041738	0.00	0.04638062
PrimaryGroup.Queue	0.00019017	0.00	0.00013857	0.00031291	0.00	0.01516466

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
AlternateGroup.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Boarding.Queue	0.00365802	0.00	0.00134269	0.00494153	0.00	1.0000
PrimaryGroup.Queue	0.00227052	0.00	0.00162825	0.00382016	0.00	1.0000

To conclude, both models averaged **286** x passengers processed spanning 6x testing iterations. The time in queue for both the boarding check and scanning processes fell well under the 15-min threshold, given the provided testing parameters within the assignment. For testing and reference purposes, I have attached both the raw Arena .doe file in addition to the two (2) x KPI reports involved in this analysis for review.