

Application of DoE to Determine Factor Settings for Optimum Internet Speed

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Abstract— People have different opinions about what affect their internet speed at home, most users believe that having a fast internet connection from the Internet Service Provider (ISP) guarantees a fast internet connection at home. A simple experiment was designed to determine the optimum settings to receive a high internet speed. The data shows that using a wire connection with google chrome afternoon on weekdays will result into a high internet connection.

Index Terms—2k factorial design, Analysis of Residual, ANOVA, Blocking, Design of Experiments, Statistical Analysis.

1 INTRODUCTION

People have different opinions about what affect their internet speed at home, so we decided to conduct an experiment to find the optimum factor settings to obtain a fast internet connection. The objective was to find out the minimum time taken to download a 10 Mb file. The goal was to find the optimum settings to download the file.

1.1 Identifying the Factors and Response

After consulting a few computer scientists, we managed to come up with the following factors:

- **Connection Type:** Internet users surf the net through two types of connections, 'Wire (Ethernet)' or 'Wireless Connection'.
- **Browser:** Although most internet users use Internet Explorer, we decided to neglect the famous browser due to its poor performance according to specialists. The top two browsers in the market nowadays are 'Chrome' from Google and 'Firefox' from Mozilla.
- **Time of the day:** The users may surf or download in the 'Afternoon' or 'Evening'. So the two levels in this factor would be: afternoon from 1:00 P.M-3P.M, and evening from 6P.M – 8P.M.

There were two other factors that were constant:

- 1- **Internet Speed**
A 15 Mb/s cable internet is provided by Comcast.
- 2- **One Computer**

Computer specifications are 2.53 GHz i5, 4 RAM. The same computer is used for all the treatments. The response variable is the 'time taken to download a 10 MB/s file.

1.2 Choice of the Design

There are three main factors to be considered in this experiment as described. Each of the factors has two levels. Hence, a 2k factorial design (k = number of factors = 3) was chosen. We considered a total of 23 (= 8) runs and one replication.

2 THE EXPERIMENT

2.1 Hypotheses Statements

The following Hypotheses were formulated for conducting the experiment.

Hypothesis Statement 1

Ho: There is no effect of the factor 'Connection Type' on the download time.

H1: There is an effect of the factor 'Connection Type' on the download time.

The above statement is mathematically expressed as:

Ho: $\mu_1 = \mu_2$

Ho: Any one μ is different

μ_1 and μ_2 are the mean times taken for downloading a file using Wire and Wireless connection.

Hypothesis Statement 2

Ho: There is no effect of the factor 'Browser' on the download time.

H1: There is an effect of the factor 'Browser' on the download time.

The above statement is mathematically expressed as:

Ho: $\mu_1 = \mu_2$

Ho: Any one μ is different

μ_1 and μ_2 are the mean times taken for downloading a file using Chrome and Firefox.

Hypothesis Statement 3

Ho: There is no effect of the factor 'Time of Day' on the download time

H1: There is an effect of the factor 'Time of Day' on the download time

The above statement is mathematically expressed as:

Ho: $\mu_1 = \mu_2$

Ho: Any one μ is different

μ_1 and μ_2 are the mean times taken for downloading a file afternoon and evening.

2.2 Conducting the Experiment

In order to conduct the experiment the design was developed using Minitab. Three factors, namely, 'Connection Type' with two levels, 'Browser' with two levels, and 'Time of the day' with two levels were put into a general linear model of the

DoE module of Minitab. Since there are three factors with two levels and one replication, the data capture form for a total of 8 experimental runs is obtained as shown in Table1.

The time taken to download the file was recorded by using a stopwatch. The experiment was conducted in the afternoon at 1.00 P.M-3 P.M and evening from 6:00 P.M-8:00 P.M. After noting down the download time, the browser is reset to delete any cache file that might help speed the download. The randomized Run Order is as shown below.

TABLE 1
EXPERIMENT DATA

Std Order	Run Order	Connection	Browser	Time	Response
5	1	Wire	Chrome	Night	2.9
6	2	Wireless	Chrome	Night	8.2
2	3	Wireless	Chrome	Afternoon	7.8
3	4	Wire	Firefox	Afternoon	2.5
7	5	Wire	Firefox	Night	3.1
4	6	Wireless	Firefox	Afternoon	8.2
8	7	Wireless	Firefox	Night	8.3
1	8	Wire	Chrome	Afternoon	2.1

3 STATISTICAL ANALYSIS

Table 2 shows the ANOVA table for the selected 23 factorial experiment. As shown from the Normal plot of effects, only main factor 'Connection Type' is significant. Interaction effect is almost negligible. There is no three-factor or higher order interaction effects. Therefore, we feel confident to say that only factor 'Connection Type' is important in this experiment. Furthermore, observation of the main effects plots of the three factors indicates that largest effect is for the factor 'Wire (Ethernet).

3.1 Main Effects and Interaction Plots

Factor 'Connection Type', has a much higher effect than the other factor as shown in figure 1. The interaction between the factors is plotted, there were no interactions found among the three factors as shown in figure 2.

3.2 Analysis of Variance (ANOVA)

The insignificant terms were taken out of the model and the ANOVA table was obtained from Minitab package. The ANOVA table is shown in Table 2.

From the table, the P-values of the effects of the factors "Connection Type" is less than 0.001 and "Browser" and "Time of Day" is 0.102 and 0.022 respectively. This proved that 'Connection Type' has a significant effect since the P-value < 0.05. On the other hand, the other two factors have P-values ≥ 0.05 which shows that they are insignificant. Also, the P-value of

the model can also be found. Hence, we reject the null hypothesis and conclude that there is at least one factor that is affecting the download speed.

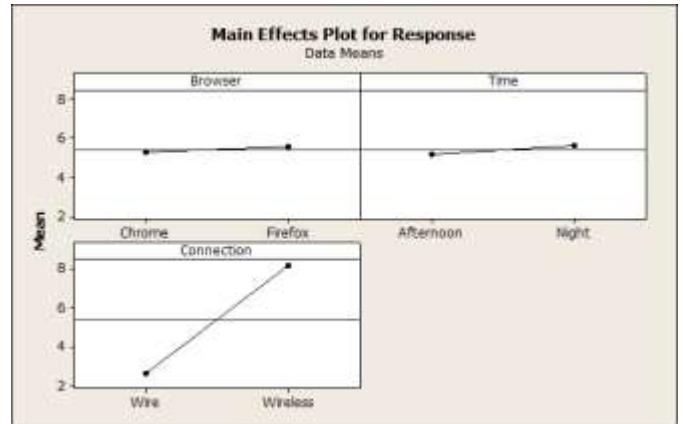


Figure 1: Main Effect

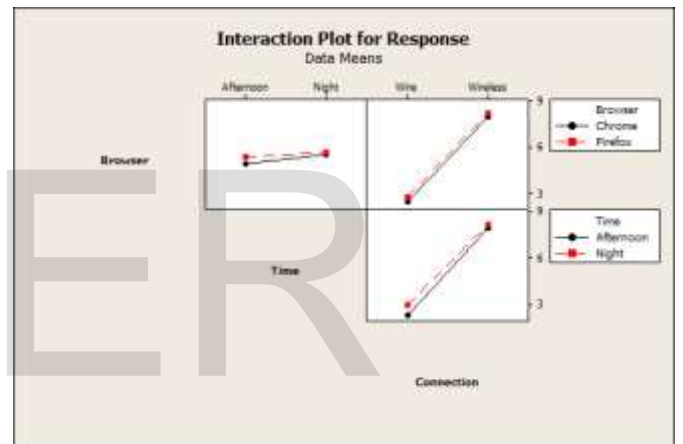


Figure 2: Interactions

TABLE 2
ANALYSIS OF VARIANCE (ANOVA)

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General Linear Model:
Factor      Type      Levels Values
Browser     fixed     2 Chrome, Firefox
Time        fixed     2 Afternoon, Night
Connection  fixed     2 Wire, Wireless

Analysis of Variance for Response, using Adjusted SS for Tests

Source      DF      Seq SS      Adj SS      Adj MS      F      P
Browser     1      0.191      0.191      0.191      4.48  0.102
Time        1      0.451      0.451      0.451      10.27  0.022
Connection  1      59.951     59.951     59.951     1776.33  0.000
Error       4      0.135      0.135      0.034
Total       7      60.688

R-Sq = 99.78%  R-Sq(Adj) = 99.61%
    
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3.3 Analysis of the Normal Graph:

The normal graph was plotted and analyzed for finding out the significant factors. After analyzing the normal graph, the data appears to be normal.

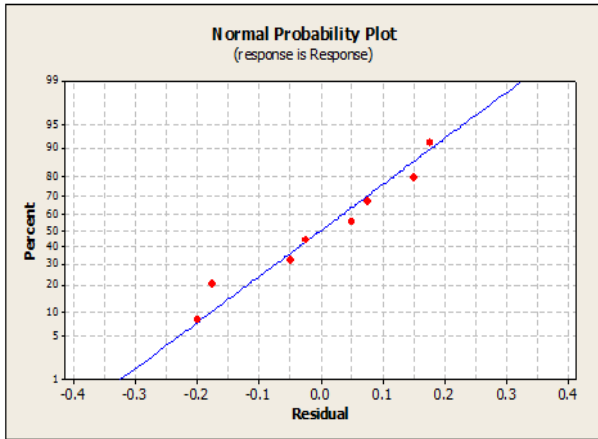


Figure 3: Normal Probability Plot

3.4 Analysis of Residual

The Residuals vs. Fits graph is plotted and we wouldn't say that the graph was very ideal but since our experiment was a 23 factorial experiment with one replicates and we had only a total of only eight readings, the graph was just satisfactory.

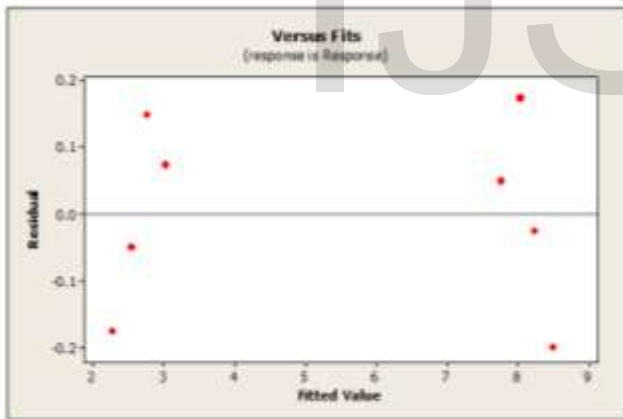


Figure 4: Residual vs Fits

Blocking

In order to find the effect of the other two factors, we blocked the connection type because of its overwhelming effect. After blocking, the main effects were easier to read as shown in figure 5. There were no interactions between the two factors.

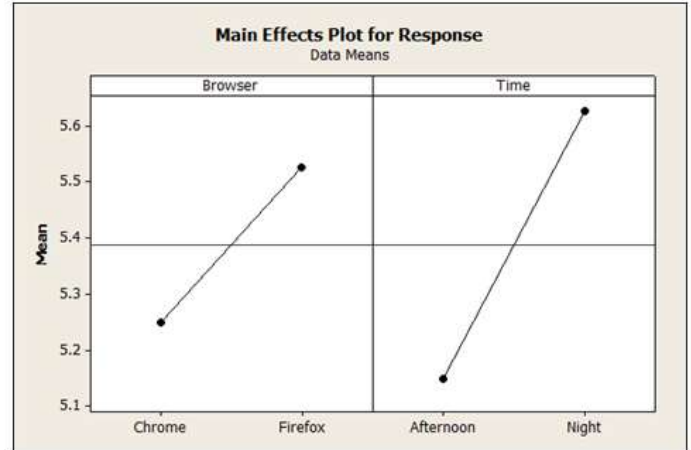


Figure 5: Main Effects after Blocking

4.2 Recommendations

After analyzing the collected data and summarizing the conclusion, we recommend the following suggestions to improve the internet speed. Recommendations can be summarized as follows:

- The user should use Wire (Ethernet) Connection.
- The user should use Google Chrome.
- The user should download afternoon during weekdays to experience a high speed internet connection at home.

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4 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusion

- The factor that significantly affects the download speed is 'Connection Type'.
- The download speed is also affected by the time of the day.
- The browser has an effect on the download speed.