

# Assignment 2 - Network Speed Data Analysis

*by Gafyn Davies*

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# Assignment Title: Network Speed Data Analysis

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**Module:** Data Analysis & Visualisation

**Module Code:** ACCB4002

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## 1.0 Introduction

This assignment evaluates the viability of the new algorithm by testing whether it reduces network latency compared to the existing algorithm. It will focus on the two datasets provided: Server 1 (current algorithm) and Server 2 (new algorithm), with each containing 42 latency measurements in milliseconds, for a total of 84 observed packets. Latency is important because lower latency shortens server response times experienced by users and applications, improving performance as well as helping to support service-level agreements (SLAs) [1]. The analysis uses exploratory data analysis followed by hypothesis testing using an appropriate t-test. Decisions will then be made based on the significance levels  $p = 0.10, 0.05$  and  $0.01$  [7]. Finally, limitations and uncontrolled variables will be discussed, controls for a stronger future evaluation will be proposed, and a recommendation will be made on whether the new algorithm should be adopted based on the evidence.

### 1.1 Investigation of Dataset

The dataset contains network latency measurements from two servers: Server 1 (existing algorithm) and Server 2 (New algorithm). The two samples are treated as independent because the latency measurements from Server 1 and Server 2 are not paired or matched observations, satisfying the independence assumption required for an independent two-sample comparison [5]. Latency is recorded in milliseconds (ms), with 84 observations in total split evenly into 42 measurements per server. The data are presented as two columns of numeric latency values alongside a packet index. Basic data-quality checks were carried out using Microsoft Excel: COUNTBLANK returned 0 for both columns, indicating no missing values. A review of the values also found no impossible measurements (e.g. negative latency). No metadata was provided, such as time of day or packet size which may influence latency.

*Table 1. Descriptive statistics for Server 1 and Server 2 latency (ms)*

| Statistics         | Server 1    | Server 2    |
|--------------------|-------------|-------------|
| Mean               | 88.87142857 | 77.54761905 |
| Standard Error     | 1.280676023 | 0.485662474 |
| Median             | 87.60       | 77.05       |
| Standard Deviation | 8.299729226 | 3.147452558 |
| Sample Variance    | 68.88550523 | 9.906457607 |
| Kurtosis           | 37.44479387 | 27.41400164 |
| Skewness           | 5.960237604 | 4.769553673 |
| Range              | 55.6        | 20.6        |
| Minimum            | 84.4        | 75.0        |
| Maximum            | 140.0       | 95.6        |
| Sum                | 3732.6      | 3257.0      |
| Count              | 42          | 42          |
| Lower Quartile     | 86.125      | 76.025      |
| Upper Quartile     | 89.275      | 78.275      |
| IQR                | 3.15        | 2.25        |
| Lower Fence        | 81.40       | 72.65       |
| Upper Fence        | 94.00       | 81.65       |

When examining the descriptive statistics, Server 1 has a mean latency of 88.87 ms and a median of 87.60 ms, whereas Server 2 has a mean of 77.55 ms and a median of 77.05 ms. This indicates that Server 2 typically has lower latency by approximately 10–11 ms, suggesting meaningfully improved responsiveness. In both datasets, the mean slightly exceeds the median, indicating right-skewness driven by a small number of high-latency observations.

Server 1 also exhibits greater variability than Server 2, with a substantially higher standard deviation (8.30 ms vs 3.15 ms), suggesting less consistent performance. Both datasets contain isolated high-latency spikes (Server 1: 140.0 ms; Server 2: 95.6 ms), which inflate the SD, particularly for Server 1. This pattern is supported by the IQR values, with Server 1 showing a wider typical spread (3.15 ms) than Server 2 (2.25 ms), indicating that Server 2’s typical latency is more consistent.

Figure 1. Boxplot comparison of latency distributions for Server 1 and Server 2 (ms), showing median, IQR, and outliers.

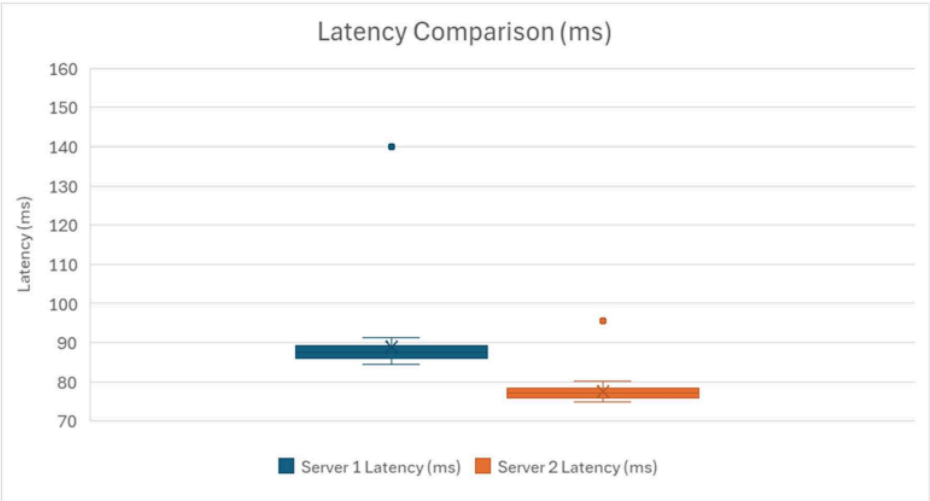


Figure 2. Histogram of Server 1 latency measurements (ms).

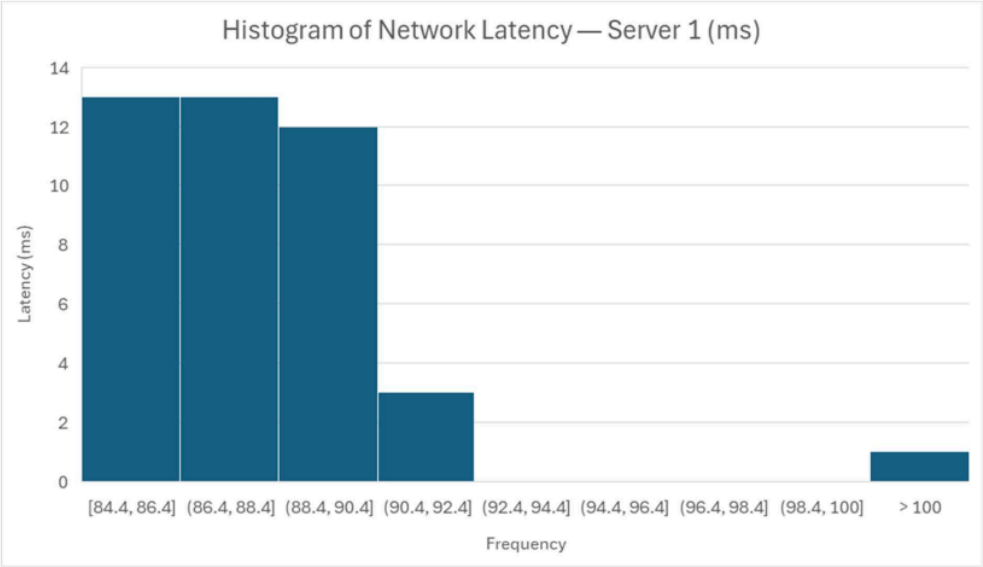


Figure 3. Histogram of Server 2 latency measurements (ms).

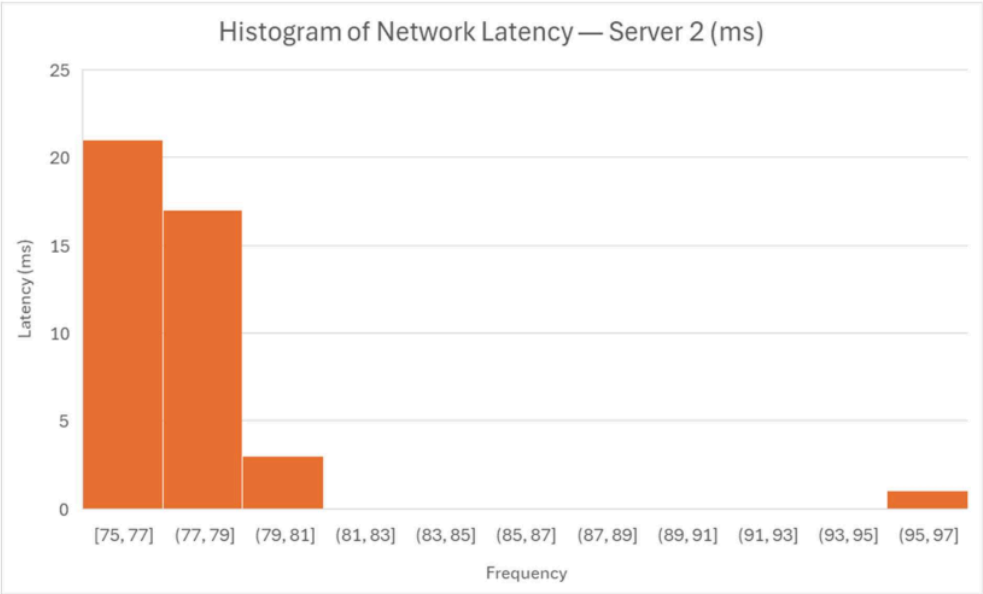


Figure 4. Latency by packet index for Server 1 and Server 2 (ms), highlighting isolated spikes.

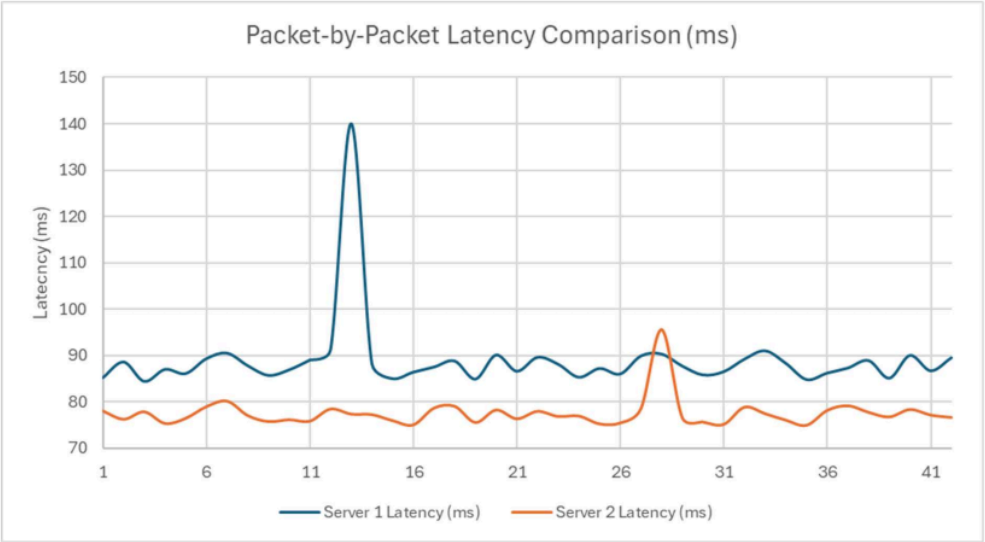


Figure 5. Scatter plot comparing Server 1 and Server 2 latency measurements (ms), showing weak co-variation

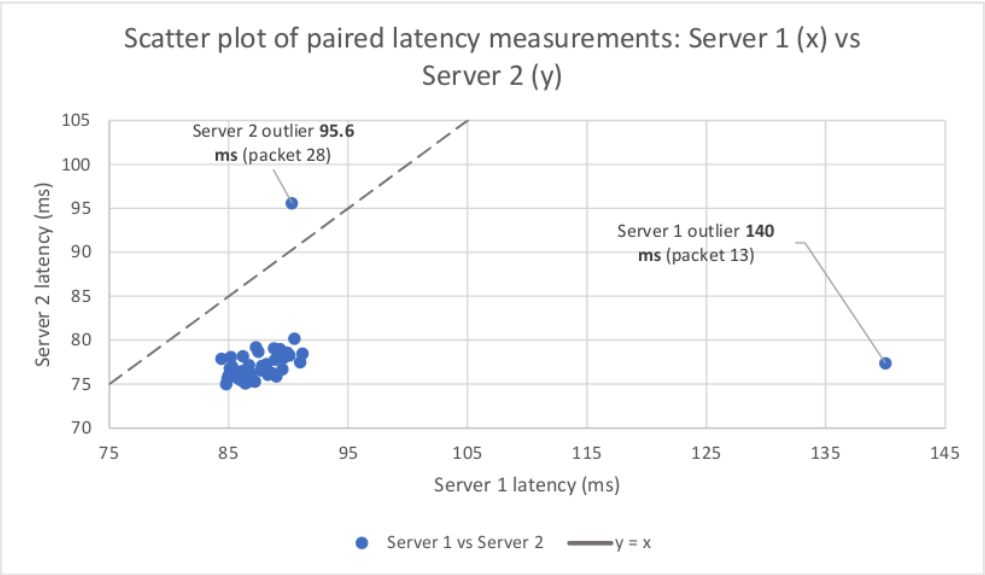


Table 2. Outlier detection summary using Tukey’s 1.5×IQR rule (ms)

| Metric | Server 1 | Server 2 |
|--------|----------|----------|
| Q1     | 86.13    | 76.03    |

|                            |       |       |
|----------------------------|-------|-------|
| Q3                         | 89.28 | 78.28 |
| IQR (Q3 - Q1)              | 3.15  | 2.25  |
| Lower Fence (Q1 - 1.5xIQR) | 81.40 | 72.65 |
| Upper fence (Q3 + 1.5xIQR) | 94.00 | 81.65 |
| Outliers flagged           | 140.0 | 95.6  |
| Packet index of outliers   | 13    | 28    |

## 1.2 Exploratory Data Analysis (EDA)

Figures 1 – 3 summarise the latency distributions, with the boxplot shows a lower median and smaller interquartile range for Server 2. This indicates a lower and more consistent typical latency. The histograms also confirm right-skewed distributions with isolated high-latency outliers, particularly for Server 1.

Figure 4 shows that latency is generally stable across packet indices, with isolated spikes rather than sustained trends. Figure 5 shows weak co-variation between Server 1 and Server 2 latency ( $r = 0.090$ ) which supports the treatment of datasets as independent samples. Correlation is interpreted as association only and does not imply causation as it only describes the strength of the linear relationship rather than the reason for it [5].

The exploratory data analysis therefore indicates right-skewed distributions with two clear outliers. As extreme values can disproportionately influence the mean and standard deviation, analyses are repeated with and without the identified outliers to assess the strength of the findings [4]. In addition, the groups showed unequal variability, making Welch's two-sample t-test appropriate as it does not assume equal variances, unlike Student's t-test, which pools variances [2]. The results are reported at  $p = 0.10, 0.05$  and  $0.01$ .

## 1.3 Outliers and Their Impact

In order to identify the outliers in the data, Analysis A will use all 42 values per server while Analysis B will remove 140.0 from Server 1 and 95.6 from Server 2 (41 values each).

*Table 3. Identified outliers (Tukey 1.5xIQR rule)*

| Server   | Outlier Value (ms) | Packet Index | Why it is flagged                                                                        |
|----------|--------------------|--------------|------------------------------------------------------------------------------------------|
| Server 1 | 140.0              | 13           | Outlier is above the upper fence (94.00 ms) using Tukey's rule ( $Q3 + 1.5 \times IQR$ ) |
| Server 2 | 95.6               | 28           | Outlier is above the upper fence (81.65                                                  |

|  |  |                                            |
|--|--|--------------------------------------------|
|  |  | ms) using Tukey's rule<br>(Q1 + 1.5 x IQR) |
|--|--|--------------------------------------------|

In order to identify any outliers, the standard 1.5x IQR [3], which defines an outlier as any value falling more than 1.5 times the interquartile range outside the first or third quartiles [4] was used. This method was used to generate the whiskers in Figure 1, highlighting the 140.0 ms (Server 1) and 95.6 ms (Server 2) data points as statistically extreme.

*Table 4. Analysis A vs Analysis B Comparison*

| Analysis A (with outliers) |             |             | Analysis B (outliers removed) |             |
|----------------------------|-------------|-------------|-------------------------------|-------------|
| Metric                     | Server 1    | Server 2    | Server 1                      | Server 2    |
| Mean                       | 88.87142857 | 77.54761905 | 87.62439024                   | 77.10731707 |
| Median                     | 87.60       | 77.05       | 87.50                         | 77.00       |
| Standard Deviation         | 8.299729226 | 3.147452558 | 1.913214636                   | 1.34469146  |
| Range                      | 55.6        | 20.6        | 6.8                           | 5.2         |
| Minimum                    | 84.4        | 75.0        | 84.4                          | 75.0        |
| Maximum                    | 140.0       | 95.6        | 91.2                          | 80.2        |
| Count                      | 42          | 42          | 41                            | 41          |
| Lower Quartile             | 86.125      | 76.025      | 86.100                        | 76.000      |
| Upper Quartile             | 89.275      | 78.275      | 89.200                        | 78.200      |
| IQR                        | 3.15        | 2.25        | 3.10                          | 2.20        |

In network performance data, rare latency spikes may represent congestion events rather than measurement error. As there was no evidence of data corruption, these values were retained in Analysis A to reflect real-world conditions. Analysis B removes the outliers as a sensitivity check to assess whether conclusions are robust to the presence of extreme events, as these can influence the mean and standard deviation [4].

*Table 5. Change in mean difference and SD after outlier removal*

|            | Mean Difference (ms) | Standard Deviation Difference |
|------------|----------------------|-------------------------------|
| Analysis A | 11.32                | 6.4                           |
| Analysis B | 10.52                | 1.8                           |

The standard deviation with the outliers removed (especially in Server 1) drops significantly by 6.4 whilst the drop in Server 2 is less significant, with it dropping by 1.8. The mean difference only changes

slightly in both, with Server 2 still showing as faster with lower latency. This suggests that the new algorithm provides a more stable and predictable performance.

## 1.4 Hypothesis

Dependant variables (DV): Latency/ping time (ms).

Independent variable (IV): Server 1 (Existing) and Server 2 (New).

### **Hypothesis A**

Hypothesis 0: That changing the algorithm will not reduce or be equal to network latency.

Hypothesis 1: The new algorithm will reduce network latency.

$$H^0: \bar{x}_2 \geq \bar{x}_1$$

$$H^1: \bar{x}_2 < \bar{x}_1$$

A one-tailed Welch two-sample t-test will be used as the samples are treated as independent and a reduction in latency is expected under the new algorithm [7]. Results are evaluated at  $p = 0.10, 0.05$  and  $0.01$ . If  $H_1$  is supported, this provides evidence that the new algorithm reduces latency and may justify wider deployment, subject to the limitations and uncontrolled variables discussed later.

## 1.5 Selection and Justification

EDA was used to inform methodological decisions before hypothesis testing, including test selection and sensitivity analysis. Due on the presence of outliers, a robustness check was implemented by comparing results from the full dataset (Analysis A) with those obtained after removing the identified outliers (Analysis B).

An independent two-sample comparison was required as the latency measurements originate from different regional servers and are not paired. Welch's two-sample t-test was selected because variability differs between groups. A one-tailed test was used as the expected effect of the new algorithm was a reduction in latency. The results are evaluated at significance levels of  $0.10, 0.05$  and  $0.01$  [7].

### **Hypothesis B**

Hypothesis 0: Server 2 is not more consistent than Server 1

Hypothesis 1: Server 2 is more consistent than Server 1.

$$H^0: \sigma_2^2 \geq \sigma_1^2$$

$$H^1: \sigma_2^2 < \sigma_1^2$$

Hypothesis B tests whether the new algorithm improves consistency, defined as lower variability in latency (smaller SD/IQR) on Server 2 compared to Server 1.

To test the variability hypothesis, a two-sample F-test for variances was performed which evaluates whether Server 2 has lower variance than Server 1. The resulting p-values will then be used to make decisions at 0.10, 0.05 and 0.01 significance levels [7].

## 1.6 T-Test

Table 6 - Welch's Two-Sample t-Test Results (Unequal Variances)

| Analysis | $\alpha$ | t Stat      | t Critical one-tail | Decision     |
|----------|----------|-------------|---------------------|--------------|
| A        | 0.10     | 8.267538785 | 1.297729843         | Reject $H^0$ |
| A        | 0.05     | 8.267538785 | 1.674116237         | Reject $H^0$ |
| A        | 0.01     | 8.267538785 | 2.398789836         | Reject $H^0$ |
| B        | 0.10     | 28.79713788 | 1.293420507         | Reject $H^0$ |
| B        | 0.05     | 28.79713788 | 1.666293696         | Reject $H^0$ |
| B        | 0.01     | 28.79713788 | 2.379262129         | Reject $H^0$ |

## 1.7 Variance Test

Table 7: Variance test results (F-test) comparing latency consistency between Server 1 and Server 2

| Analysis   | Data Condition   | Variance (Server 1) | Variance (Server 2) | F Statistic | Decision at $\alpha = 0.10$ | Decision at $\alpha = 0.05$ | Decision at $\alpha = 0.01$ |
|------------|------------------|---------------------|---------------------|-------------|-----------------------------|-----------------------------|-----------------------------|
| Analysis A | With outliers    | 68.89               | 9.91                | 6.95        | Reject $H_0$                | Reject $H_0$                | Reject $H_0$                |
| Analysis B | Without outliers | 3.66                | 1.81                | 2.02        | Reject $H_0$                | Reject $H_0$                | Fail to reject $H_0$        |

Table 7 summarises the results of the variance tests for Hypothesis B. With outliers included, Server 1 shows considerably greater variance than Server 2, which also shows strong evidence at all significant levels. After removing the outliers, the variance difference is still significant at 0.10, 0.05 but not at 0.01. This suggests the variance result is sensitive to extreme values, making the conclusion that Server 1 is less consistent than Server 2 less robust once the outliers are removed.

## 1.8 Results and Discussion

### Hypothesis A

The descriptive statistics indicate that Server 2 consistently shows lower average latency than Server 1. In Analysis A (with outliers), Server 2 shows a mean latency of 77.55ms compared with 88.87 ms for

Server 1, representing an average reduction of 11.32 ms. In Analysis B (outliers removed), the mean latency remains lower for Server 2 (77.11 ms) compared with Server 1 (87.62 ms), with a similar mean reduction of 10.52 ms.

Welch's two-sample one-tailed test was used to formally test whether the new algorithm reduces mean latency. For Analysis A, the test produced a large positive t-statistic ( $t = 8.27$ ) with an extremely small p-value ( $p < 0.01$ ), leading to rejection of the null hypothesis at 0.10, 0.05 and 0.01 significance levels. The results were even stronger for Analysis B ( $t = 28.80$ ,  $p < 0.01$ ), again leading to the rejection of the null hypothesis at all three significance levels, leaving Hypothesis A unchanged when the outliers are removed.

### **Hypothesis B**

Hypothesis B examined whether the new algorithm improves consistency by reducing variability in latency. In order to test this hypothesis, an F-test for variances was used to compare Server 1 and Server 2.

In Analysis A (with outliers), Server 1 shows higher variance than Server 2 ( $F = 6.95$ ,  $p = 0.01$ ), leading to the rejection of the null hypothesis at 0.10, 0.05 and 0.01. This indicates that Server 2 is significantly more consistent when rare latency spikes are included.

In Analysis B (outliers removed), Server 1 again shows higher variance than Server 2 ( $F = 2.02$ ). The p-value ( $p = 0.014$ ) indicates statistical significance at 0.10 and 0.05 but not at 0.01. This suggests that while Server 2 remains more consistent under typical conditions, the strength of evidence is reduced once extreme spikes are excluded. Overall, both hypothesis shows results that are robust in handling outliers, although the strength of evidence for improved consistency is more sensitive when extreme values are present.

## **1.9 Interpretation**

The results provide strong evidence that the new routing algorithm reduces the average network latency. With the reduction being significant at 0.05 and 0.01 levels, results indicate that the reduction in latency is unlikely to be random chance. This conclusion is consistent across both analysis which increases the reliability and confidence of the findings.

With an average reduction of 10-11 ms, the improvement in performance is meaningful, as lower network latency improves responsiveness for users and applications [1]. It may also contribute to improved service and compliance with service-level agreements. This improvement remains consistent, even when outliers are removed, suggesting that the benefit applies to typical network performance rather than it being a rare occasion.

The results for Hypothesis B indicate that the new algorithm not only reduces latency on average but also delivers more consistent performance. While the strength of the evidence is reduced with the removal of the rare latency spikes, the cleaned analysis still suggests improved consistency under normal operating conditions. This is important to note as variance-based measures are particularly sensitive to extreme values.

Although the statistical tests provided strong evidence of reduced latency under the new algorithm, the evidence provided should be interpreted as association rather than definitive causation. Because

the data was collected from two different regional servers rather than under controlled experimental conditions, unobserved factors such as background traffic or routing topology may have partially caused the observed differences. Nonetheless, the consistency of the results across each analyses suggests that the new algorithm is likely to play a meaningful role in the performance improvement.

## 1.10 Assumptions and Limitations

Several assumptions are made throughout this analysis. First, the two datasets are treated as independent samples as they originate from different regional servers. Second, it is assumed that the latency measurements represent typical network performance, despite being limited to 42 observations per server.

It is also important to note that the sample size provided was relatively small and was provided with no metadata e.g. no data was provided regarding the time of day, network load, packet size or routing path, all of which could influence latency. Tests that are based on variance such as the F-test used are also sensitive to departures from normality and the presence of outliers, potentially impacting the interpretation [4]. In future analysis, a more robust alternative such as Levene's test or Brown-Forsythe test should be used as these tests are less affected by skewness and extreme values and can therefore give a more reliable comparison of variability when data contains outliers [6].

There are also several other factors that influence the latency differences such as regional load differences, network path length and routing topology and the time of day the data was recorded (during peak and off-peak hours). As these may impact the latency, addressing these in any future experiments would strengthen confidence in the results.

To account for the observed variance differences between the two servers, Welch's t-test was employed to bypass the requirement for equal variance. While balanced sample sizes can sometimes mitigate the risk of variance inequality, Welch's t-test was chosen as it provides more stable Type 1 error rates and remains robust [3]. This ensured the analysis accurately reflected the distribution patterns identified during the exploratory phase.

## 1.11 Recommendations

Based on the results, it is recommended that the new routing algorithm proceed to a wider pilot so that development can continue. The algorithm demonstrates a statistical and meaningful reduction in average latency, alongside improved consistency under most conditions. The findings are robust to the treatment of outliers, which increases confidence in their reliability.

A full rollout of the algorithm should not occur until additional testing has been done as future tests should include collected metadata, an increase in sample size and where possible, the use of controlled A/B testing within the same region. This would allow clearer isolation of the algorithm's effect and a reduction of uncontrolled external factors.

## 2.0 Conclusion

This assignment evaluated the impact of a new routing algorithm on network latency using performance data from two regional servers. Exploratory data analysis indicated lower typical latency and reduced variability for the server running the new algorithm, which was then later confirmed using inferential statistical testing.

Welch's two-sample t-test provided strong evidence that the new algorithm reduces mean latency, with statistically significant results at 0.10, 0.05 and 0.01, both with and without outliers. A secondary analysis of variance showed that Server 2 is also more consistent, although the strength of this evidence decreases when extreme values are excluded.

While the results support the use of the new algorithm, limitations related to sample size and uncontrolled variables must be taken into consideration. Overall, the evidence suggests that the new algorithm could improve performance however further testing will need to be carried out before it can be implemented.

### 3.0 Reference List

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- [2] R. M. West, "Best practice in statistics: Use the Welch t-test when testing the difference between two groups," Annals of Clinical Biochemistry: International Journal of Laboratory Medicine, vol. 58, no. 4, p. 000456322199208, Feb. 2021, doi: <https://doi.org/10.1177/0004563221992088>.
- [3] B. Derrick, D. Toher, and P. White, vol. 12, no. 1, 2016, Available: <https://www.tqmp.org/RegularArticles/vol12-1/p030/p030.pdf>
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- [6] I. Parra-frutos, "The behaviour of the modified Levene's test when data are not normally distributed," Computational Statistics, vol. 24, (4), pp. 671-693, 2009. Available: <https://www.proquest.com/scholarly-journals/behaviour-modified-levenes-test-when-data-are-not/docview/220393125/se-2>. DOI: <https://doi.org/10.1007/s00180-009-0154-z>.
- [7] M. R. Spiegel and L. J. Stephens, Schaum's Outline of Statistics, 4th ed. New York, NY, USA: McGraw-Hill, 2008.

# Assignment 2 - Network Speed Data Analysis

## GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

93/100

| Generic Assessment Criteria                                                                                                                                                | Marks available | Marks awarded |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|---------------|
| 1. Engagement with Literature Skills                                                                                                                                       | 10              |               |
| Bibliography and referencing present and good.                                                                                                                             |                 | 9             |
| 2. Knowledge and Understanding Skills                                                                                                                                      | 30              |               |
| Very good knowledge demonstrated of the outliers and, the descriptive stats, and good discussion of their impacts.<br><br>Good consideration of correlation and f testing. |                 | 29            |

|                                                                                                                                                                                                                                                   |    |    |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|----|
| <b>3. Cognitive and Intellectual Skills</b>                                                                                                                                                                                                       | 30 |    |
| <p>Well written interpretation of results with a good amount of detail, however it may have been advantageous to explicitly declare acceptance or rejection of H1.</p> <p>Good consideration of calculation with and without outliers though.</p> |    | 28 |
| <b>4. Practical Application Skills</b>                                                                                                                                                                                                            | 20 |    |
| <p>A well constructed experiment with multiple hypotheses and techniques undertaken. Well done.</p> <p>Good evidence of statistical test in figures and of descriptive stats through a good use of tables and graphs.</p>                         |    | 20 |
| <b>85. Transferable Skills for Life and Professional Practice</b>                                                                                                                                                                                 | 10 |    |

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| Substantially over the wordcount,<br>however,<br>very well presented and written report. |  | 7 |
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