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CHALLENGES IN SIGNIFICANT ADOPTION OF ACTIVE QUEUE MANAGEMENT IN THE PHILIPPINES' CONSUMER SPACE

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Active Queue Management, Consumer Adoption, COVID-19, Bufferbloat

1. INTRODUCTION

In an increasingly digital world, a strong and robust internet infrastructure is paramount; this is more so considering the context in which this paper was made: during the Severe Acute Respiratory Syndrome — CoronaVirus 2 pandemic, colloquially known as COVID-19. With major events around the world being moved to a virtual medium in light of the virus spreading through respiratory droplets, the internet is increasingly utilized to compensate for productivity in many fields, including but not limited to the academe and commercial — events that generally can be held from the comfort of an individual's home. Hence, the aforementioned need for a robust internet is essential since any further disruptions will increase the losses of productivity that have been incurred due to the global pandemic. This premise is given weight thanks to the medium of these events: video conferencing applications such as Zoom have risen to prominence thanks to the need for virtually distant conferences. In light of this, video conferencing is a latency-sensitive application which requires that the latency of the internet is kept at a minimum to avoid video and audio degradation. Additionally, latency-sensitive activities such as Voice over IP (VoIP), Video Streaming, and Online Gaming are some of the other examples where sudden increases in latency prove significantly detrimental. This phenomenon in internet networks is known as bufferbloat; according to DSLReports, this is characterized as "the undesirable latency caused by routers and cable/DSL modems buffering more data than necessary." One of the mitigations that is present thanks to the Institute of Electrical and Electronics Engineers (IEEE) is Active Queue Management (AQM), characterized as the management of data packets via proactively dropping packets before it exceeds the buffer, preventing excessive latency thanks to heavy load. Therefore, this study seeks to examine the reasons as to why AQM is noticeably absent in the Internet of Things: consumer electronics space.

2. PROBLEM STATEMENT

The best-case scenario of this research is that it is applied to reality; active queue management is adopted commercially en masse in the commercial market both in consumer and enterprise settings. However, in spite of research clearly demonstrating the clear benefits of AQM implementation both quantitatively and qualitatively, it is a concept that is poorly understood by the average consumer in the Philippines and limited to enthusiasts willing to experiment on open-source firmware. Hence, the majority of consumers have little to no knowledge of excessive latency that comes as a result of heavy network use; this then causes significant delays when

using applications that require a stable connection leading to a myriad of negative consequences — most prevalent being a loss of productivity. With all this mentioned, this paper seeks to resolve the issue by tackling the factors that inhibit the widespread adoption of AQM in the Philippine network equipment space.

3. RESEARCH GAP

Majority of the existing literature that is available pertains to the concept of AQM itself rather than application of the concept into real-world use. With the clear benefits of its mass implementation, this paper will provide the bridge from concept to real-time use by examining the possible reasons for its lack of adoption by the mass market and providing the appropriate recommendations.

3.1. Research Question

What are the factors that limit the wide scale Philippine market adoption of Active Queue Management in the consumer electronics space?

3.2.Research Objectives

1. Examine the current market knowledge on bufferbloat;
   a. Understand the demographics of those using the internet;
   b. Determine the impact of latency in their digital day-to-day actions;
   c. Determine the value of the aforementioned mitigation in the consumer market.

2. Opine as to the reasons as to the lack of market adoption of anti-bufferbloat mitigations based on data;
   a.Use data collection as to infer reasons through deductive reasoning.
3. Provide recommendations;
   a. Utilize the aforementioned quantitative data and possible reasons for lack of market adoption to provide solutions.
4. Disrupt the Internet of Things: consumer electronics space;
   a. Via the research paper, increase the reach of anti-bufferbloat mitigations into the consumer market;
   b. Provide a consumer profile for certain budgets so as to increase market reach.
   c. Attempt to bridge the gap, through the use of this research, between the concept of AQM and into the hands of consumers.

3.3.Review of Related Literature

According to Chi (2020), the paper asserts that modern telecommunications are essential in today's technologically adept population, along with the premise that higher internet speeds are positively correlated with the economic status of a country. With these two statements, this gives a clear foundation for the basis of the introduction — a robust infrastructure being a must. Additionally, on the same paper, it asserts that the improvement of telecommunications is a must in order to provide better opportunities for all Filipinos who increasingly rely on access to the internet in order to have a chance at improving their quality of life; with this, further pretext is given to the necessity of a strong base for the telecommunications industry. Without a strong industry, the mitigations given to solve bufferbloat will have minimal impact if the internet constantly goes out thanks to poor reliability from internet providers. Furthermore, the impact of

these anti-bufferbloat mitigations is also lost if the power grid infrastructure is not fully developed. Power outages will cause a loss of internet given the logical premise that these are connected to electricity. Hence, in conclusion, this source proves relevant given the foundation it provides for the requirements needed to give AQM a consistently meaningful impact.

Another related research on this topic is on the concept of Active Queue Management itself. For instance, the concept was formalized into actual use by the IEEE in 1993 according to Adams (2013); from this, conclusions can be inferred. One, with respect to the context in which AQM was appearing in research papers, it can be opined that signs for the internet were already on the point for civilian use. Coincidentally, this was also the time where Berners-Lee introduced the concept of the World Wide Web (WWW): a way for the internet to be bridged from military use to general civilian use. Hence, with the increase in data packets moving as a result of the increased reach of civilians using the internet, the problem of buffers being full quickly due to said increase in data packets leading to internet degradation would arise. Therefore, because of this, AQM models have been examined by multiple organizations seeking to solve the problem.

Initial frameworks that involved the AQM system during the 1990s-2000s were the Tail Drop and the Random Early Detection algorithms. These are characterized as two methods in which packets that are incoming whilst the buffer is full is effectively dropped. This means that the data incoming will not be accepted into the current buffer until the buffer can allocate can process the existing data packets. The tail-drop method has its limitations: for instance, this method is a passive method of AQM. Based on a previous lecture on internet protocols from NC State University in 2014, “Tail drop is a passive queue management algorithm. In this algorithm, the traffic is not differentiated and each packet is considered to be at the same priority. Also, the main consideration here is the maximum queue length at each router and its services using the first in first out algorithm.” This effectively does not differentiate between latency-sensitive packets and only adjusts the buffer once it’s full. Hence, it has a significant shortcoming since it does not factor in differing types of packets that require a higher priority than others. According to a paper published by the IEEE in 2002, Random Early detection is inherently limited considering that RED is inflexible with respect to the paper mentioning “A drawback in deploying RED stems from its apparent tuning difficulties. As we now show, we believe this difficulty stems in large part to RED’s use of average queue length.” Since it uses an average, limitations inherent to using an average are applicable such as susceptibility to extremes and inaccuracies in data throughput in order to make the RED algorithm tailor-made to the concerned network. Furthermore,

More developed frameworks have been developed in order to compensate for the weaknesses of the initial algorithms as mentioned above. For instance, the development of Fair Queue — Controlled Delay (FQ — CoDel) by Jacobson and Nichols in 2012 non-exhaustively improves on the initial frameworks of Tail-Drop and RED on the following:

1. It is parameter-deficient, meaning that it is inherently easier to configure considering networks with dynamic throughput;
2. CoDel also is able to determine certain types of traffic: those that cause bufferbloat, and those that don’t.
    a. Those that don’t are effectively ignored by the AQM algorithm, whilst those that are will be subjected to the algorithm to minimize delay as much as possible.
3. Implementation is simple, so it can be utilized in consumer-grade products and in high- end networking hardware.

Given the effectiveness of FQ — CoDel in reducing bufferbloat, a study has been made to examine the feasibility of implementation into network equipment for commercial use. A study

conducted by White and Rice in 2013 has shown significant benefits when correctly implementing the use of CoDEL and other AQM implementations such as ProportionalIntegral Controller, that was mentioned above, and Stochastic Fair Queuing with CoDel. Surprisingly, AQM is already present in existing cable modems as of the time of this research paper and was just not implemented by operators; when configured optimally, it has been quantitatively and qualitatively shown that improvements in latency are significant. This, however, is only limited to upload speeds and does not examine the download side, what many households use. Hence, this paper is valuable in proving that the theoretical algorithms do make a meaningful difference in internet experience.

Over the years, research has been made in order to see which AQM algorithm is the most optimized for network traffic. According to a paper written by Arora and Singh in 2015, with the current AQM implementations that they were able to examine, they determined that Stochastic Fair Queuing was the best algorithm for implementation of reducing excessive delay when it comes to heavy network utilization. This is relevant considering that there have been many AQM implementations that have been proposed by researchers across the world, seeking to solve the issue of bufferbloat.

However, in the course of attempting to find the best AQM algorithm available, there has been a clear lack of standardization of metrics in order to quantitatively measure the results of researchers' algorithms in order to determine what algorithm is best all-around in order to see which implementation of AQM should be actively used in the real-world. Fortunately, research done in 2019 by Khatari, Zaidan, Zaidan, Albahri, and Alsalem is able to provide two general metrics that developers of future AQM algorithms should use in order to benchmark performance. Specifically, they recommend merging the processes of Analytic Hierarchy Process (AHP) along with Technique in Order of Preference by Similarity to the Ideal Solution (TOPSIS) in order to create a new benchmarking standard that is ideal for new AQM algorithms to be tested against: promoting robustness and quality.

Perhaps another clear application of the effectiveness of AQM is in big data: significant amounts of data running through a server at once. Given that big data requires quick execution of data processing with mass inputs into meaningful outputs to be of use to experts, it also requires that the connection to the internet for this is responsive (i.e., latency-free). Hence, an examination was made to see whether or not AQM would provide a tangible benefit in Hadoop clusters and in the MapReduce Programming Model. Given the analysis of the research that has been done, it has also shown that bufferbloat can be reduced significantly, by 85% whilst only increasing the Hadoop execution time using the MapReduce Model by 5%. However, it strongly cautions that getting the configuration right is the only way to achieve optimal results, as poor configurations lead to increases in Hadoop executions and non-ideal reductions in bufferbloat. Hence, it can be concluded that AQM is clearly scalable in many settings, from the confines of one's home to the large data processing units that are used by technology companies to process large amounts of information.

As of today, in open-source software, AQM has more developments. In OpenWrt, an open-source Linux base for networking hardware such as routers and wireless extenders, the implementation of Cake (Common Applications Kept Enhanced) — from the Bufferbloat community —has provided for further improvements in solving this problem. This discipline for queuing network packets considers AQM as only one of the measures necessary in order to address bufferbloat. Cake includes the following:

1. Traffic Shaper
2. Priority Queue

3. Flow Isolation
4. AQM
5. Packet Management

All of these factors lead to reduced latency in general internet use, especially in latency- sensitive applications and has factored in additional information that makes the difference between a low-latency internet and one that is significantly crippled by bufferbloat.
Additionally, cake is superior to CoDel, non-exhaustively, in a couple of ways:

1. Command Line interface is simpler than CoDel;
2. Reduced CPU Load thanks to an integral shaper;
3. Explicit Congestion Notification (ECN) is always on, avoiding false positives;
4. Ease of availability;
    a. Since it is on Linux, an open-source platform, it is easily available with commands understood on the aforementioned platform.

With all of this, it shows the progression of AQM into actual practice and is relevant to gain a better understanding of the merits of applying this into the consumer market, especially in light of the COVID-19 pandemic, and its impacts still forcing many events and industries to go virtual, as any sign of latency means missed productivity which often proves to be major.

Majority of the research mentioned so far has pointed to the progression of AQM; another field of research that is relevant from a second field of view is of consumer behavior. Characterized as "how people buy goods and services", this field is especially important if one wants to appeal to consumers effectively and thus end up with the latter buying the goods and services that are offered. Given the complexity of the concept that is being marketed to appeal to consumers, the concept proves relevant.

For instance, Consumer Behavior: 11th Edition has relevant concepts that are of value. When it comes to effectively appealing to consumers, there are four elements in order to properly understand consumer behavior: Motives, Cues, Responses, and Reinforcement. These are characterized as:

1. Motives
    a. The incentive behind doing something;
2. Cues
    a. The mechanism in which consumers will know that a certain product/service is what they need (e.g., Marketing, Advertising);
3. Responses
    a. How the consumer reacts to the former two factors;
4. Reinforcement
    a. The way in which consumers are solidified towards believing a certain view.

In terms of how to create effective advertising, there are many effective avenues: comparative advertising, appeal to humor, fear, and sexual appeal. These avenues are defined as follows:

1. Comparative Advertising
    a. By making claims that one's product is superior to the competition, this appeals to consumers since they only want what's best for them;

2. Appeal to Humor

   a. Through the use of advertising to induce laughter, it promotes a positive brand image and leaves a long-term impact;

3. Appeal to Fear
   a. By presenting a clear threat that consumers should be fearful of, and providing a solution to said fears, it promotes consumers to buy your products for a sense of safety.

4. Sexual Appeal
   a. Through this method, consumers are captivated by an ideal human image. This, however, requires careful execution. Else, consumers will only be captivated on the model and not the product.

These are important for a complex concept such as bufferbloat, since the value of the algorithm in question is not apparent to an average person. It will require a simplification of the concept in order for average consumers to understand the value.

Extending on consumer behavior, another research paper proves its value given the recency of the paper. A paper made by Moon, Choe, and Song in 2021 describes consumer behavior in South Korea in light of the COVID-19 pandemic; a majority of respondents would prefer to acquire their goods online rather than getting goods in person in light of personal safety. With this, it can be argued via the use of the Protection-Motivation Theory; this is simply explained as protection being the first reason for their actions and with that framework in mind, people will gravitate their decisions for the sake of protection.

Another relevant part of a business is pricing and how deciding how much or little a product or service is priced has a meaningful impact on whether or not a consumer would purchase said product or service. Given a research paper by Quan, Quan, and Wang in 2019, consumers' expectations play a factor as to influencing pricing. On one hand, if consumers' expectations are very high for the product in question and prioritize psychological satisfaction, the price is effectively damaged and the same goes with profits. This is because a higher standard is required — and this compels the seller to reduce prices in order to not disappoint them. On the other hand, if a consumer is only expecting the bare minimum and does not prioritize their happiness, prices can rise and profits by extension. This is due to their perspective on only focusing with the product in question getting the job done. Given that one of the goals of this paper is to create a potentially disruptive business, the goal is to reach as many customers as possible.

Lastly, of relevance is consideration for how consumers are influenced in terms of their purchases specifically with Internet of Things devices. For the most part, the study by Tsourela and Nerantzaki in 2020 concludes that there are certain factors that play a larger role in a consumer as to whether or not they will buy a product under this category. Of particular note is trust. When a consumer has confidence in a brand's products and services through superior customer experience, perceived ease of use, and a proven track record, adoption is significantly hastened. On the other, factors such as social influence do play a part though to a lesser extent against the factors aforementioned.

4. THEORETICAL FRAMEWORK

With the available literature, the concept of Active Queue Management itself is only available with no research papers on examining the actual limitations of full market adoption; hence, this warrants the use of an individual framework unique to this research in order to fully ascertain the reasons for the lack of market adoption. Given that the market is the body that is directly concerned with the apparent lack of adoption, marketing fundamentals make the most sense to apply as a theoretical framework.

Regarding the use of marketing fundamentals, parts of a market plan — according to Pearson's 17th Edition of Principles of Marketing — make most sense in applying here; for instance, parts of this paper can already be used for the current marketing situation such as the market description, existing products and competition. Additionally, using the Strengths, Weaknesses, Opportunities and Threats and substantiating them with inferences obtained from the quantitative data also proves relevant as another framework in making clear the variables necessary. Lastly, marketing actions will be manifested in itself as recommendations. Essentially speaking, this is a market reach problem, basics in marketing are used for the majority of the paper to solve the question of the lack of market adoption in the internet of things — consumer electronics space.

In this case, the foundational framework that is most applicable will be thematic analysis. Considering the nature of the research question which requires that factors be fleshed out in order to sufficiently answer the question, dividing the independent variables (factors) into themes will be of use to the fulfillment of this research paper. Hence, there will be no use of hypothesis testing when it comes to the information that has been obtained along with corresponding analysis and discussion as a result.

Consequently, given no hypothesis testing, what the data will be used for is to determine the extent of the veracity of the hypotheses that will be mentioned in the latter part of this paper. In other words, the goal is to determine to what extent the hypotheses are true in the context of the data that has been obtained, and whether or not said data confirms or rejects the possible factors That answer the research question at hand **Hypothesis**

The hypotheses are as mentioned:

1. Consumers' lack of knowledge on Active Queue Management prevents them from proactively seeking out the solution to a poor internet experience;
    a. Given that many are not cognizant on a basic level on what bufferbloat is.
2. A complex topic such as Active Queue Management is, in itself, an additional barrier for a consumer to better understand the primary mitigation available to them;
    a. Marketing such a feature and pointing out its value proves difficult.
3. The technical execution required in order to have the option available to them is far too high, with only individuals proficient in network consumer electronics being willing to attempt flashing open-source firmware;
    a. With risks such as damaging the internet device (whether hardware or software) and limited compatibility with some models.
4. Current networking equipment players perceive no immediate benefit to implementing Active Queue Management in their consumer electronics.

6. METHODOLOGY

The primary mechanism in order to successfully answer the research question will primarily be done through data collection; through the input of respondents, information relevant to the research objectives will be revealed via a survey questionnaire. A secondary method will be via the use of existing literature from relevant and quality sources.

6.1. Respondent Profile

Information obtained from respondents such as age, employment, income bracket, will provide relevant information as to how they are influenced in their purchase decisions and their preferences in the context of this study.

6.2. Sample Collection and Size

For the purposes of this study, a sample of 200 respondents will be obtained from multiple areas of the country (in Luzon, Visayas, and Mindanao) in order to provide a diverse picture of their perceived wants in order to promote an ideal internet experience.

6.3. Data Collection Method

The variables in this paper will be ascertained via an online survey which is distributed to respondents. A prototype of the survey has already been made to ensure that the base version is fully functional; hence, a final version was made with questions that have been tweaked to be more relevant to the study. Consequently, the sampling technique that was used for this paper is non-probability based; in particular, convenience and snowball sampling are the prevalent mechanisms used.

6.4. Questionnaire

Survey questions are segmented into five parts which contain questions that ask for certain information; the Likert scale was often used to determine the respondents' inclinations to agreeing or disagreeing to certain statements. Additionally, open-ended questions were used to factor in a variety of responses that respondents may give to certain questions which requires to be flexible about the context of the respondent.

6.5. Tools

Data that has been obtained through the questionnaire will be analyzed via IBM's SPSS and Microsoft Excel with PH Stat 4.1 in order to tabulate, organize, and analyze the data; the primary mechanism of analysis is through the cluster method: done in order to create a customer profile; three segments have been made for the sake of the objectives mentioned above. Standard statistical treatment will also be utilized: Sample Mean, Median, Mode, Standard Deviation; this will be relevant in analysis of the data that has been given by respondents and will promote a representative picture so as to not be perceived as tone-deaf.

6.6. Budget

This group possesses the following characteristics:

- A Monthly Income of Minimum Wage Up Until Less Than ₱22,000;

- Spending ₱500 - ₱2,000 for Internet Usage Monthly; ●Knows Little to Moderate Knowledge on Bufferbloat, And;
- Prefers Buying Technology Products Physically.

Hence,

- A Budget Router with a Low Production Cost and Low Sale Cost is Attractive; ○Must be Cheap but Robust in Terms of Build Quality;

  ■ Low Specifications:

- Basic Single to Dual Core, Medium Frequency CPU (MIPS)
- 8 MB of Flash
- 64 MB of RAM

○Providing Basic Wi-Fi Standard;

■ Wireless Protected Access 2 (WPA
■ Low-Powered Antennas:

●Maximum of 20 decibel-milliwatts (dBm)

○Simple, Yet Intuitive User Interface;

■Modes for Simple to Complex Users

- Examples: Wireless Access Point, Router Mode

■Left to Right Layout
■Larger Sans Serif Fonts to Emphasize Important Menu Options
■Easy Upgrade Options to Maintain Security

- Product Must be Built on Relationships with Physical Retailers and Resellers Along with Online Option to Increase Availability;

○Given the Cluster's Preference for Physical Purchases and Competition Against Larger Network Manufacturing Companies.

6.7. Mid-Range

This group possesses the following characteristics:

- A Monthly Income of ₱22,000 Up Until Less Than ₱132,000;
- Spending ₱2,000 - ₱5,000+ for Internet Usage Monthly;
- Knows Little to Moderate Knowledge on Bufferbloat, And;
- Prefers Buying Technology Products Physically.

Hence,

- A Mid-Range Router with Slightly Higher Production Cost and Increased Price is Attractive:

- ○An Increased Budget for Specifications and Better Build Design;
  - ■Medium Specifications:
- Dual to Quad Core, Medium to Higher Frequency CPU (Higher-Tier MIPS to Low-Tier ARM)
- 8-16 MB Flash
- 64-128 MB RAM
  - ■Providing Slightly Better Wi-Fi Standard:
- Wireless Protected Access 2 (WPA 2)
- Medium Powered Antennas
  - ○Maximum of 25 decibel-milliwatts (dBm)
  - ■Simple, Yet Intuitive User Interface;
- Modes for Simple to Complex Users
  - ○Examples: Wireless Access Point, Router Mode
- Left to Right Layout
- Larger Sans Serif Fonts to Emphasize Important Menu Options
- Easy Upgrade Options to Maintain Security
- Product Must be Built on Relationships with Physical Retailers and Resellers Along with Online Option to Increase Availability;
  - ○Given the Cluster's Preference for Physical Purchases and Competition Against Larger Network Manufacturing Companies.

6.8. High-End

This group possesses the following characteristics:

- A Monthly Income of ₱132,000 Up Until ₱220,000+;
- Spending ₱2,000 - ₱5,000+ for Internet Usage Monthly; ●Knows Little to Moderate Knowledge on Bufferbloat, And;
- Prefers Buying Technology Products Physically.

Hence,

- A Flagship Router with the Best Specifications that are Currently Available:
  - Significantly Increased Specifications and Build Quality:
    - ■Dual Core, Higher Frequency to Quad, or Octa Core CPU (Higher-Tier ARM to x86)
    - ■16-32 MB Flash ■128 MB RAM +
  - ○Latest Wi-Fi Standard:
    - ■Wireless Protected Access 3 (WPA 3)
    - ■High Powered Antennas:
- Maximum of 30 decibel-milliwatts (dBm)
  - Simple, Yet Intuitive User Interface;
    - ■Modes for Simple to Complex Users
- Examples: Wireless Access Point, Router Mode
    - ■Left to Right Layout
    - ■Larger Sans Serif Fonts to Emphasize Important Menu Options
    - ■Easy Upgrade Options to Maintain Security

- Product Must be Built on Relationships with Physical Retailers and Resellers Along with Online Option to Increase Availability;
    - ○Given the Cluster's Preference for Physical Purchases and Competition Against Larger Network Manufacturing Companies

7. CONCLUSION

7.1. Research Value

Given the objectives of the research paper at hand, this paper has proven on a quantitative level that the hypothesis holds true. Clearly, a majority of respondents are unable to find a meaningful answer to bufferbloat and thus provides significant demand for a networking equipment solution at the consumer level. Though reading this paper, one can understand from a sample of respondents in the Philippines that Filipinos are clearly frustrated with their experience when it comes to their internet and there is clearly a prospective market given the significant perceived value for security, latency management, service, customizability, and differentiation.

With the use of the data analysis and the customer profile via cluster analysis, a guideline has been made for the Philippine context when it comes to the specifications given their income levels and cost of internet use monthly. As mentioned in the literature review, there are substantial quantitative and qualitative benefits when it comes to an optimal implementation of Active Queue Management. Should this be implemented on a commercial scale for consumers, this would be of major benefit to consumers which will increase productivity during this pandemic — especially when productivity is already compromised.

Consequently, when the internet infrastructure proves to be robust and extremely responsive, this further allows for the exchange of information on a faster rate. Although the effects of anti-bufferbloat measures may be not apparent from an individual standpoint immediately, the benefits accumulate over time in the form of saved time, increased productivity, and increased research into the latest standards of networking given the widespread implementation and its clear merits. This improves the sharing of information on a great scale, improving the well- being of a country. By extension, keeping said country competitive in the Fourth Industrial Revolution.

7.2. Research Limitations

Despite the clear value of the research on a widespread problem that impacts many Filipinos significantly, said research is ultimately limited when it comes to whether or not the research is actualized into reality. This paper will be of no value if it is simply left as is, without being applied into the real world. Though the paper does provide an eye-opener with regards to internet woes in the Philippines, that is not the primary objective of the paper in and of itself.

Furthermore, another flaw in this research is the method of data collection; with the use of non-random sampling, researcher bias will be apparent. Thus, this is to the detriment to the paper since the quality of data collection categorically suffers; moreover, another significant flaw of this paper is the fact that there is only one person that is responsible for the entirety of the paper. This plays a major factor considering that if there was another co-author in the creation of this research, the data sample can be vastly diverse which provides a representative picture and is able to examine the feasibility of the above recommendations on a global scale. By proxy, with another member, the literature review can be expanded significantly which can further validate and give a clearer picture of the research at hand.

7.3. Recommendations

Factoring both value and limitations, there are some meaningful recommendations that can be made to enhance successive research. Firstly, by changing the sampling method to a probabilistic nature, this would increase the representation of the sample, although this will require more time since probabilistic sampling is much more difficult in terms of procurement.

Secondly, another recommendation would be to expand this research to other countries. This is valuable because it allows for this research to be validated on a global scale. Through the use of many perspectives, this allows for generalization which then makes understanding of the networking equipment industry much easier given its complexity.

Lastly, given that this is the first research paper when it comes to applied networking concepts, more research should be made into this endeavor. One objective of this paper is to be a bridge from concept to reality. This paper alone proves insufficient in this endeavor and will require rich research in order to make that bridge firm and increase the adoption rate of new technologies in this network equipment space, both in software and hardware.

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