Broadband Technologies in Elementary and Secondary Schools in Southwestern Ontario

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Abstract

This report presents a comprehensive evaluation of broadband technologies in schools located in Southern West Ontario. The study was conducted using data collected from the School Boards, and it involved meticulous data preparation, rigorous methodologies, and insightful analysis.

One of the key focus areas of the study was to investigate the impact of weather on internet connectivity. This is an important factor to consider, as inclement weather can cause disruptions in internet service, which can significantly affect the digital learning experience of students. By examining the performance metrics, reliability, and historical usage patterns of broadband technologies, the study provides valuable insights that can help optimize technology resources and enhance the digital learning experience.

Another focus area of the study was to develop a predictive model for device utilization in schools. This is an important consideration, as it can help educational institutions allocate their technology resources more efficiently. By analyzing historical usage patterns and other relevant data, the study provides valuable insights that can help schools better understand their technology needs and make more informed decisions about resource allocation.

The findings of this study are particularly significant, as they contribute to bridging the digital divide and facilitating efficient resource allocation for educational technology in Southern West Ontario schools. By providing insights into the performance, reliability, and historical usage patterns of broadband technologies, the study can help schools optimize their technology resources and enhance the digital learning experience of their students. This, in turn, can help bridge the digital divide and ensure that all students have equal access to high-quality educational resources.

In summary, this report provides a detailed and insightful evaluation of broadband technologies in schools located in Southern West Ontario. The study's rigorous methodologies, insightful analysis, and valuable findings make it a valuable resource for educational institutions seeking to optimize their technology resources and enhance the digital learning experience of their students.

Acknowledgements

We would like to express our sincere gratitude to Connecting Windsor Essex for their support and partnership in this project. Their contribution has been instrumental in enabling us to carry out this research and develop the analysis tools.

We would also like to extend our heartfelt thanks to the School Boards, our client organization, and St. Clair College for providing us with the opportunity to work on this project. Their support and collaboration have been crucial in ensuring the success of this study.

We would like to offer a special acknowledgment to Dan Circelli for his invaluable assistance and guidance throughout this project. His expertise and dedication have been indispensable to the project's success.

Finally, we would like to express our appreciation to our mentors, Manjari Maheshwari and Tomasso, for their guidance and support throughout this project. Their insights and feedback have been instrumental in shaping the direction and scope of this research.

Content

INTRODUCTION

Reliable and high-speed internet is essential for digital learning in schools worldwide, including Southern West Ontario. This report thoroughly evaluates broadband technologies in schools, analysing their performance and identifying areas for improvement.

The report uses data from School Boards, ensuring accuracy and reliability. It assesses different broadband technologies' performance, including parameters like latency, jitter, and ping, to understand their strengths and weaknesses.

The report also examines the impact of weather on internet connectivity, recognizing the importance of uninterrupted access to online resources. It suggests ways to enhance reliability and mitigate potential connectivity issues.

A predictive model for device utilization in schools is also presented, leveraging historical data on device usage patterns. This model helps educational institutions allocate resources efficiently and plan infrastructure better, improving technology utilization and efficiency.

The report's recommendations will guide educational institutions, policymakers, and technology providers in Southern West Ontario towards enhancing digital infrastructure and supporting effective educational practices. It emphasizes bridging the digital divide and ensuring equitable access to reliable broadband connectivity, which are essential for inclusive and innovative learning environments.

Overall, this report provides valuable insights for educational institutions in Southern West Ontario and beyond, supporting their efforts to improve the digital learning experience for students and educators.

Description of Project

This project endeavors to address the crucial need for high-quality broadband services in schools to facilitate effective teaching and learning. It aims to assess the state of broadband quality and usage in various school boards in Southwestern Ontario, where increasing reliance on such services for online learning, research, and communication has become increasingly apparent. Despite this need, there exists a lack of understanding regarding broadband quality and usage in local schools, which hinders the ability of schools to provide optimal learning experiences for students. By conducting a comprehensive analysis of broadband usage and quality in local schools, this project aims to provide valuable insights into the strengths and weaknesses of current broadband services and make recommendations for improvements, ultimately paving the way for more effective and efficient educational experiences for students. This report is based on a comprehensive dataset consisting of network performance metrics and connectivity statistics from Two School Boards in Southern West Ontario. The dataset covers four high schools and four elementary schools, each represented by six worksheets within separate files, spanning a period of five months. In total, there are 160 files available for analysis.

The dataset captures various broadband technology parameters, such as latency, jitter, and ping, providing insights into performance and reliability. Before analysis, data cleansing techniques were employed to remove outliers and ensure data quality. Additionally, variables were normalized for standardized analysis.

The selected schools represent a specific School Board, providing a focused view of the broadband technology landscape and utilization patterns in the region. The dataset accounts for infrastructure and educational variations across different school levels.

This comprehensive dataset forms the foundation for subsequent analysis, facilitating the evaluation of broadband technologies and the identification of potential improvements in the Southern West Ontario school system. The dataset's quality and comprehensiveness ensure that the analysis results are robust, reliable, and provide valuable insights to optimize technology resources, enhance the digital learning experience, and support effective decision-making in the region's educational institutions.

Hypothesis

- The download and upload speeds are related to the values of ping and jitter, and they are inversely proportional to each other.

- The broadband quality parameters, such as download and upload speeds, ping, and jitter, are related to weather conditions. It is hypothesized that download and upload speeds are inversely proportional to inclement weather, while ping and jitter are directly proportional.

- Broadband quality parameters, such as download and upload speeds, ping, and jitter, depend on the technology used for data delivery, such as fiber optics, coaxial cables, or cellular networks. The hypothesis is that download, upload speeds are directly proportional to the technology used, while ping and jitter are inversely proportional.

- The number of users and the number/types of applications being used can affect broadband quality parameters such as download and upload speeds, ping, and jitter. The hypothesis is that download, upload speeds are inversely proportional to the number of users and the number/types of applications being used, while ping and jitter are directly proportional.

- Broadband quality parameters, such as download and upload speeds, ping, and jitter, may also depend on the time of day and day of the week when the network is used the most. It is hypothesized that download and upload speeds are inversely proportional to peak usage time and peak usage day of the week, while ping and jitter are directly proportional.

- Broadband quality parameters may also depend on the Internet Service Providers (ISPs) or carriers. It is hypothesized that download and upload speeds, ping, and jitter may vary for different ISPs under the same conditions depending on the equipment and technology used by them.

Description of Data

PHASE(i)

This project consists of many datasets provided by the stakeholders and collected by our group by conducting some surveys as well. At the starting of the project, we were provided by some sample datasets on 27th February, with Rogers, MNSi and Bell provider coming from different servers which are Toronto, Vancouver, and Montreal. These providers use two different technologies to transmit their data. Those two technologies are Fibre and Cellular. There were different columns in these datasets which are listed as Date, Time, IP Address, Download Speed, Upload Speed, Ping, Jitter, Server, Provider and Technology. We were asked to understand this dataset and told that the data might be in the same format as the sample dataset. This was all about the sample dataset that we were provided at the beginning.

	A	B	C	D	E	F	G	H
1	Date	Upload Speed (Mbps)	Download Speed (Mbps)	Ping (ms)	Jitter	Server	Provider	Technology
2	Feb 8, 2023, 2:56:35 PM	58.70	59.40	26.99	5.95	Toronto	MNSi	Fibre
3	Feb 8, 2023, 3:01:34 PM	90.00	118.00	46.00	8.14	Toronto	MNSi	Fibre
4	Feb 8, 2023, 3:06:34 PM	68.60	17.60	23.78	1.86	Toronto	MNSi	Fibre
5	Feb 8, 2023, 3:11:34 PM	74.20	58.40	36.85	3.15	Toronto	MNSi	Fibre
6	Feb 8, 2023, 3:16:35 PM	43.40	54.20	37.53	8.81	Toronto	MNSi	Fibre
7	Feb 8, 2023, 3:21:34 PM	72.10	37.30	33.87	6.55	Toronto	MNSi	Fibre
8	Feb 8, 2023, 3:26:34 PM	31.30	19.40	22.34	44.34	Toronto	MNSi	Fibre
9	Feb 8, 2023, 3:31:34 PM	26.10	28.40	10.00	6.33	Toronto	MNSi	Fibre
10	Feb 8, 2023, 3:36:34 PM	73.10	42.90	11.49	10.51	Toronto	MNSi	Fibre
11	Feb 8, 2023, 3:41:34 PM	33.40	88.90	26.09	15.31	Toronto	MNSi	Fibre
12	Feb 8, 2023, 3:46:34 PM	36.30	69.60	38.95	6.74	Toronto	MNSi	Fibre
13	Feb 8, 2023, 3:51:34 PM	51.10	34.90	24.66	23.70	Toronto	MNSi	Fibre
14	Feb 8, 2023, 7:43:23 PM	46.80	58.00	36.00	2.20	Toronto	Bell	Fibre
15	Feb 8, 2023, 7:45:18 PM	88.30	85.40	9.70	13.20	Toronto	Bell	Fibre
16	Feb 8, 2023, 7:50:19 PM	96.70	85.00	13.19	2.16	Toronto	Bell	Fibre
17	Feb 8, 2023, 7:55:19 PM	32.00	94.70	23.71	11.03	Toronto	Bell	Fibre
18	Feb 8, 2023, 8:00:19 PM	100.40	72.30	9.76	5.02	Toronto	Bell	Fibre
19	Feb 8, 2023, 8:05:18 PM	56.50	97.60	10.35	31.88	Toronto	Bell	Fibre
20	Feb 8, 2023, 8:10:19 PM	78.80	63.10	38.70	2.57	Toronto	Bell	Fibre

	A	B	C	D	E	F	G	H	I
1	Date	Time	IP Address	Upload Speed (Mbps)	Download Speed (Mbps)	Ping (ms)	Jitter	Server	Technology
2	2023-02-15	9:52:35 PM	142.126.95.26	273	345.4	6.997	2.35	Rogers	Cellular
3	2023-02-15	9:51:12 PM	142.126.95.26	365.1	391.2	8.389	1.31	Rogers	Cellular
4	2023-02-15	9:42:35 PM	142.126.95.26	311	415.5	6.944	0.46	Rogers	Cellular
5	2023-02-15	9:37:35 PM	142.126.95.26	207.6	393.3	7.823	2.32	Rogers	Cellular
6	2023-02-15	9:34:40 PM	142.126.95.26	242.7	157	7.464	0.7	Rogers	Cellular
7	2023-02-15	9:17:35 PM	142.126.95.26	250.6	323.5	7.377	1.14	Rogers	Cellular
8	2023-02-15	9:12:35 PM	142.126.95.26	284.3	377.9	7.559	4	Rogers	Cellular
9	2023-02-15	9:07:35 PM	142.126.95.26	393.9	217.7	21.659	1.89	Rogers	Cellular
10	2023-02-15	9:02:35 PM	142.126.95.26	377.6	221.7	18.816	0.32	Rogers	Cellular
11	2023-02-15	8:57:35 PM	142.126.95.26	71.2	249.2	31.574	0.76	Rogers	Cellular
12	2023-02-15	8:52:35 PM	142.126.95.26	277.1	400.7	6.65	1.04	Rogers	Cellular
13	2023-02-15	8:47:35 PM	142.126.95.26	184.8	217.6	20.276	3.38	Rogers	Cellular
14	2023-02-15	8:42:35 PM	142.126.95.26	341.7	219.6	21.696	1.88	Rogers	Cellular
15	2023-02-15	8:37:35 PM	142.126.95.26	68.1	218	34.261	0.23	Rogers	Cellular

PHASE (ii)

After the sample dataset provided to us we were told that the school boards are not comfortable in sharing their data with the Connecting Windsor Essex company. So, we decided to collect the data through surveys. We then created a survey that was distributed among the students in the college and all the members in our group shared the data with our friends and relatives to collect the data. With all our efforts we were able to collect a total of 50 responses but that was not enough for our project. This survey was our second dataset that we had. It consists of features like Download, Upload, Jitter, Ping, Latency, Providers.

	A	C	D	E	L	M	N	O	P	Q
1	ID	What is your address	what is the postal code	Provider	Download Speed(MBPS	Uploading speed(Mbp	Latency(M	Uploading latency(M	Jitter(M	Packet loss
2	1	603 Bridge avenue	N9B2M5	Bell	64	64.4	176	492	58	0.00
3	2	605 Bridge avenue	N9B2M5	Bell	63.6	58.7	195	285	63	0.00
4	3	603 bridge avenue	N9B2M5	Bell	63.6	14.1	175	480	60	0.00
5	4	6 tangleridge Blvd Brampton	L6r2x3	Bell	566 mbps	524 mbps	18	92	1	1
6	5	179 McMurchy Ave Road South	L6Y1Z2	Rogers	100mbps					
7	6	605 bridge avenue	N9B2M5	Bell	63.6	59.8	180	182	60	0.00
8	7	436 Mill Street Windsor Ontario	N9C 2R6	Cogeco	426	127	127	61	61	
9	8	caron ave	n9a 5b4	Cogeco	300	200	143	14		
10	9	123 east side drive	M8Z 5S5	Cogeco	8.83	4.61	63	224	58	0.0
11	10	Bridge avenue	N9B2M5	Bell	63.5	59.3	190	232	61	0
12	11	St. Clair College Centre for the Arts	N9A5K4	others	336.23	285.34	30	232	7	0
13	12	St. Clair College Centre for the Arts	N9A5K4	others	168	243	90	839	58	1
14	13	St. Clair College Centre for the Arts	N9A5K5	others	30.7	26.7	107	16	1	0
15	14	St. Clair College Centre for the Arts	N9A5K5	others	30.8	26.8	126	12	0	1

PHASE (iii)

After an unsatisfactory response to our survey, we reached out to Connecting Windsor Essex once again to inquire about the response from the school boards. It was discovered that they were still in the process of convincing the school boards to provide the necessary data for the project. However, during this time, the company was able to obtain a limited amount of data that was subsequently shared with us. This data set encompasses information regarding the bandwidth server and associated technology from February 8th to February 15th, 2023. The dataset is composed of various columns, including Date, IP Address, Upload Speed, Download Speed, Ping, Jitter, Server, Provider, and Technology

M15

	A	B	C	D	E	F	G	H	I	J	K
1	Date	IP Address	Upload Speed (Mbps)	Download Speed (Mbps)	Ping (ms)	Jitter	Server	IPV6 Supported	DNSSEC Resolved	Provider	Technology
2	Feb 8, 2023, 2:56:35 PM	1x2.xxx.xxx.xxx	58.70	59.40	26.99	5.95	Toronto	0	0	MNSi	Fibre
3	Feb 8, 2023, 3:01:34 PM	1x2.xxx.xxx.xxx	90.00	118.00	46.00	8.14	Toronto	0	0	MNSi	Fibre
4	Feb 8, 2023, 3:06:34 PM	1x2.xxx.xxx.xxx	68.60	17.60	23.78	1.86	Toronto	0	0	MNSi	Fibre
5	Feb 8, 2023, 3:11:34 PM	1x2.xxx.xxx.xxx	74.20	58.40	36.85	3.15	Toronto	0	0	MNSi	Fibre
6	Feb 8, 2023, 3:16:35 PM	1x2.xxx.xxx.xxx	43.40	54.20	37.53	8.81	Toronto	0	0	MNSi	Fibre
7	Feb 8, 2023, 3:21:34 PM	1x2.xxx.xxx.xxx	72.10	37.30	33.87	6.55	Toronto	0	0	MNSi	Fibre
8	Feb 8, 2023, 3:26:34 PM	1x2.xxx.xxx.xxx	31.30	19.40	22.34	44.34	Toronto	0	0	MNSi	Fibre
9	Feb 8, 2023, 3:31:34 PM	1x2.xxx.xxx.xxx	26.10	28.40	10.00	6.33	Toronto	0	0	MNSi	Fibre
10	Feb 8, 2023, 3:36:34 PM	1x2.xxx.xxx.xxx	73.10	42.90	11.49	10.51	Toronto	0	0	MNSi	Fibre
11	Feb 8, 2023, 3:41:34 PM	1x2.xxx.xxx.xxx	33.40	88.90	26.09	15.31	Toronto	0	0	MNSi	Fibre
12	Feb 8, 2023, 3:46:34 PM	1x2.xxx.xxx.xxx	36.30	69.60	38.95	6.74	Toronto	0	0	MNSi	Fibre
13	Feb 8, 2023, 3:51:34 PM	1x2.xxx.xxx.xxx	51.10	34.90	24.66	23.70	Toronto	0	0	MNSi	Fibre
14	Feb 8, 2023, 7:43:23 PM	1x2.xxx.xxx.xxx	46.80	58.00	36.00	2.20	Toronto	0	0	Bell	Fibre
15	Feb 8, 2023, 7:45:18 PM	1x2.xxx.xxx.xxx	88.30	85.40	9.70	13.20	Toronto	0	0	Bell	Fibre
16	Feb 8, 2023, 7:50:19 PM	1x2.xxx.xxx.xxx	96.70	85.00	13.19	2.16	Toronto	0	0	Bell	Fibre
17	Feb 8, 2023, 7:55:19 PM	1x2.xxx.xxx.xxx	32.00	94.70	23.71	11.03	Toronto	0	0	Bell	Fibre
18	Feb 8, 2023, 8:00:19 PM	1x2.xxx.xxx.xxx	100.40	72.30	9.76	5.02	Toronto	0	0	Bell	Fibre
19	Feb 8, 2023, 8:05:18 PM	1x2.xxx.xxx.xxx	56.50	97.60	10.35	31.88	Toronto	0	0	Bell	Fibre
20	Feb 8, 2023, 8:10:19 PM	1x2.xxx.xxx.xxx	78.80	63.10	38.70	2.57	Toronto	0	0	Bell	Fibre

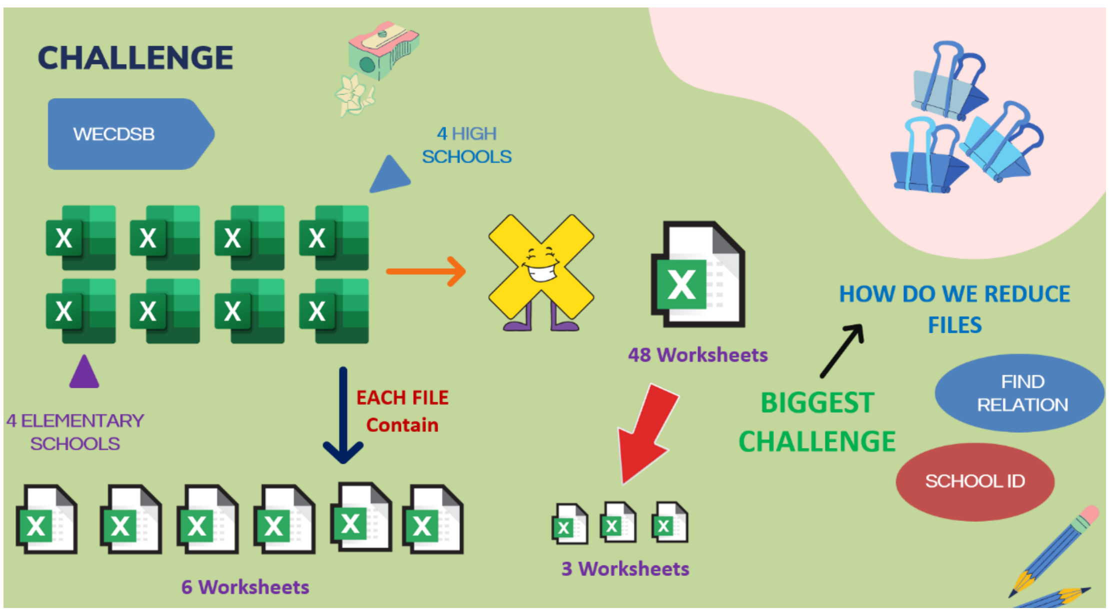
PHASE (iv)

This study utilizes two datasets consisting of network performance metrics and connectivity statistics from two prominent school boards in Southwestern Ontario, namely**, Windsor Essex Catholic District School Board (WECDSB)** and **Lambton Kent District School Board (LKDSB)**. The datasets cover a total of four high schools and four elementary schools in WECDSB for the duration of six months (September 2022 to February 2023). In LKDSB, there are eight schools, with each school having two different files for the **SD-WAN Report and Throughput Utilization Billing Report, covering a period of five months** (September 2022 to January 2023).

The selected schools provide valuable insights into the broadband technology landscape and utilization patterns in the region, accounting for the infrastructural and educational variations across different school levels. The datasets serve as a significant resource in the study of the quality and performance of broadband services in schools and can offer valuable information to aid in the development of effective educational strategies and policies.

Data cleaning

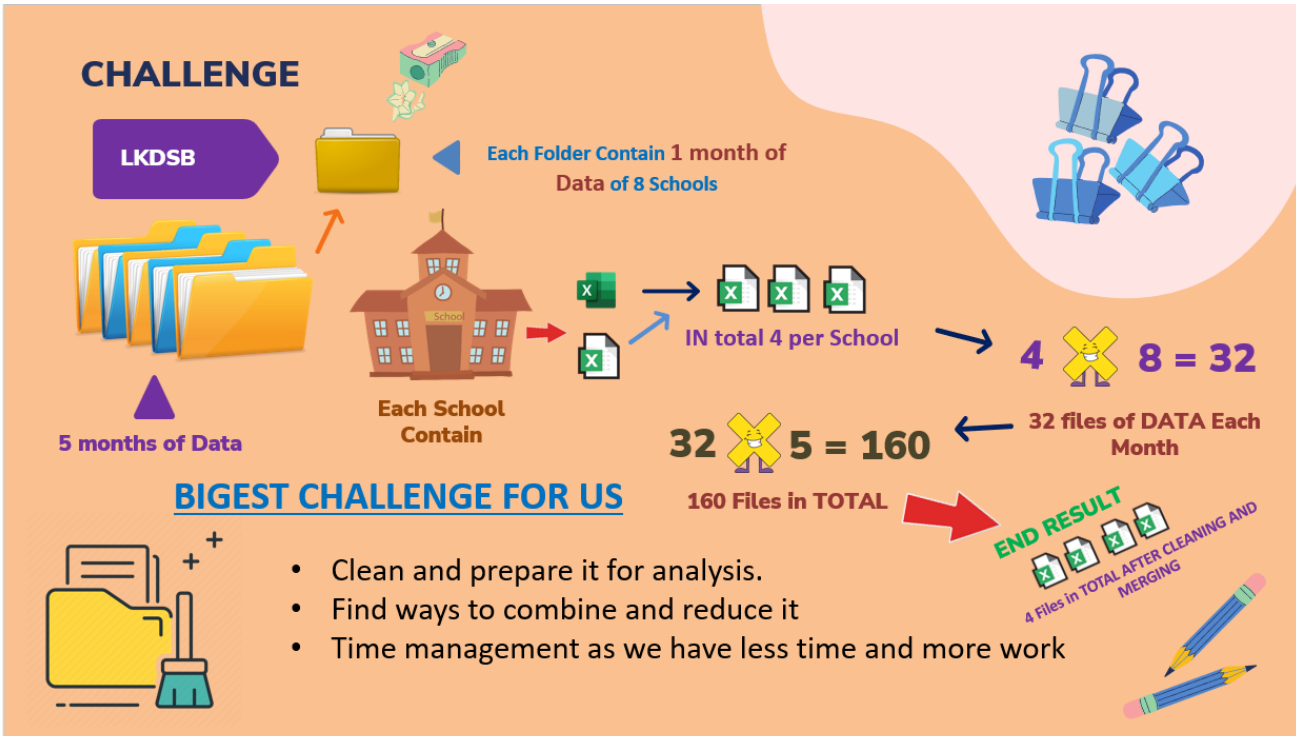
- **Windsor-Essex Catholic District School Board**
  As part of the cleaning process for WECDSB data, eight files were analyzed, four of which contained data for four different high schools and the remaining four files contained data for elementary schools. Each of these excel files consisted of six individual worksheets, resulting in a total of 48 worksheets. To streamline and organize the data, school IDs were assigned to their respective files, and the files were merged using Python based on their school IDs. The data was thoroughly cleaned and processed, resulting in a final output of three consolidated worksheets. This method allowed for a more efficient and effective management of data, providing a clearer picture of school performance, and facilitating better decision-making.



- **Lambton Kent District School Board**
  The Lambton Kent District School Board provided us with two distinct datasets, namely the SD-WAN Report and Throughput Utilization Billing Report. Upon reviewing the SD-WAN report, it became apparent that the data was presented in a format that was not easily understandable. Specifically, the dates were recorded in UNIX timestamp format, which posed significant challenges in identifying and interpreting the data.

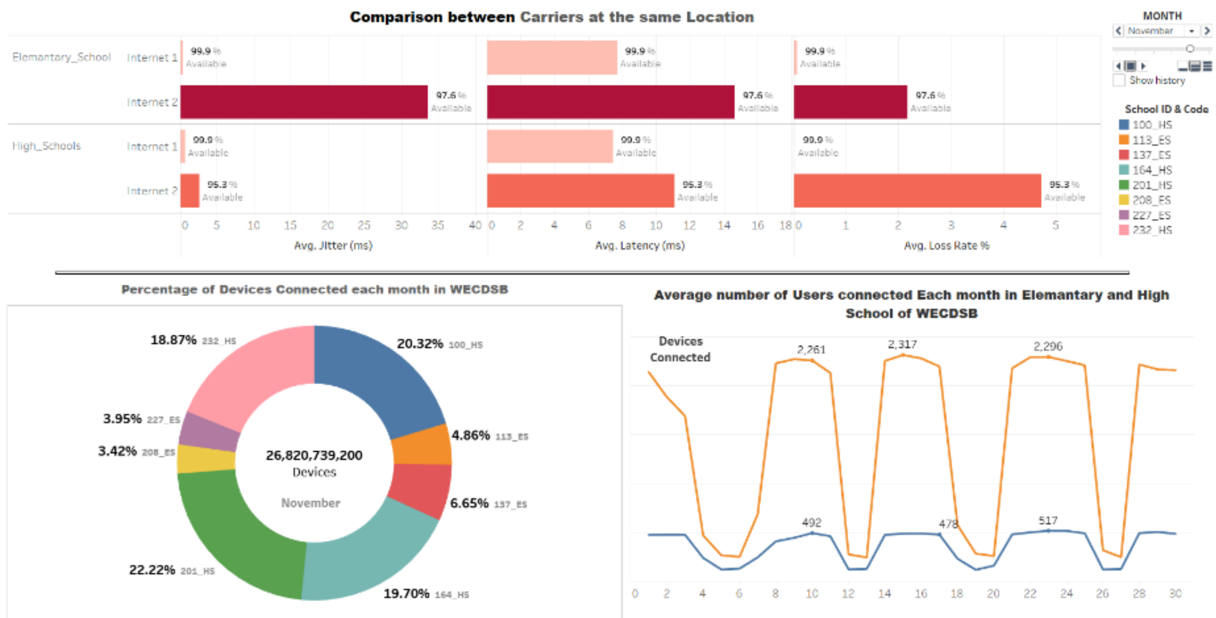
  The dataset contained essential parameters such as Jitter, Latency, and packet loss, among others. Furthermore, it contained data about the availability of different ports through which devices are connected. The various parameters upon which latency, jitter, and packet loss were collected include After SD-WAN Implementation, Device Interface summary by bandwidth over a WAN link during the specified period, and By link and SLA rules over time on port1.

Additionally, the dataset features traffic utilization by SD-WAN members over time, as well as the number of packets sent and received in bites per second on the specified port. While the data format presented some challenges, it remains a valuable resource for exploring the performance and quality of broadband services in schools.

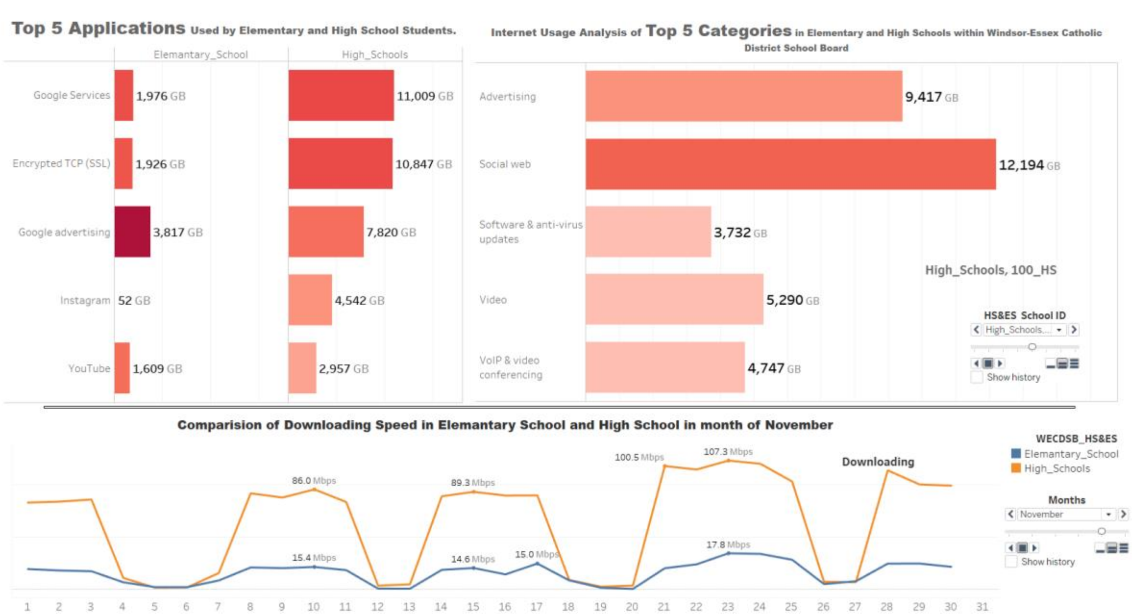


Visualization

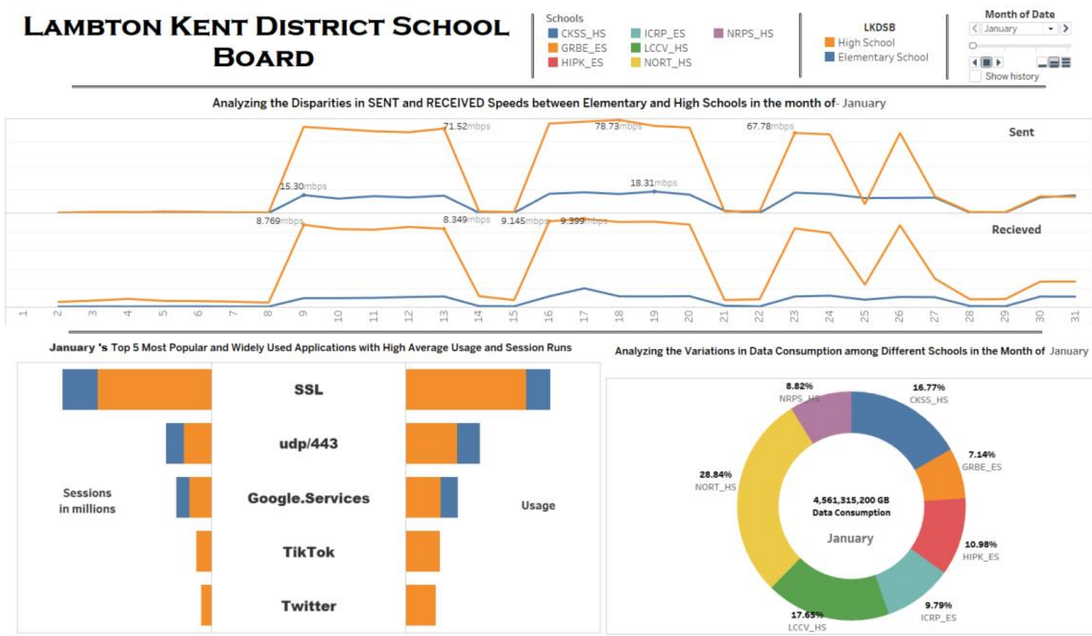
Dashboard 1:



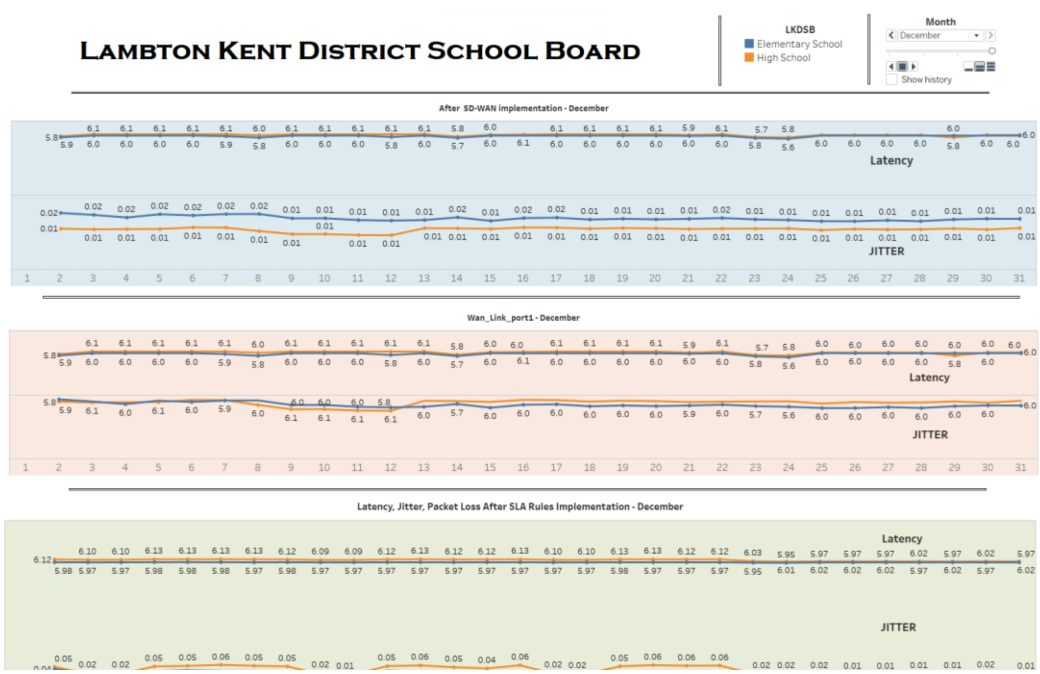
Dashboard 2:



Dashboard 3:



Dashboard 4:



Dashboard 5:

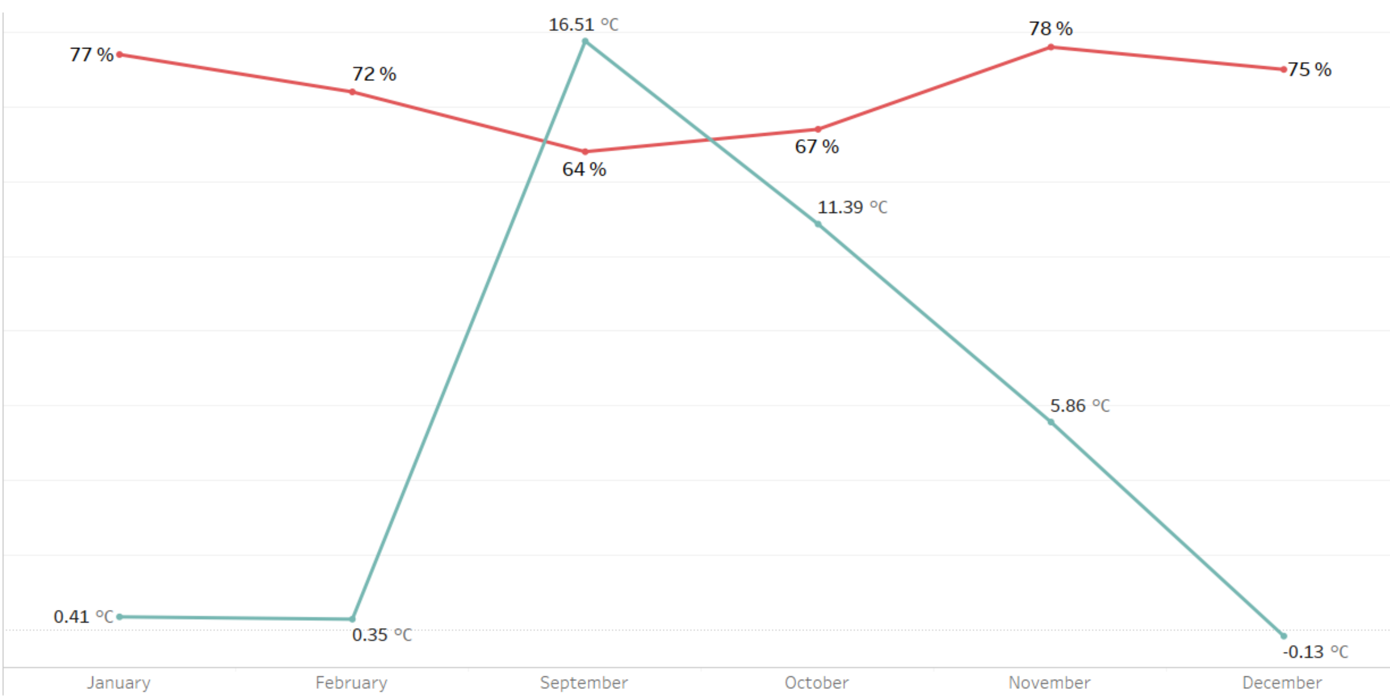
Key Performance Parameters(KPI's)
Download(Mbps)
3
Avg. Upload(Mbps)
23
Avg. Jitter After SD-WAN I..
0
Avg. Latency After SD-WA..
6
Avg. Packet Loss After SD-..
0
Avg. Traffic_Utilization(Gb)
18,348
School Type
(All)
Month
(All)
Downloads Vs Uploads speeds
Date
September
October
November
December
January
Value
21.06
2.52
26.29
3.13
21.92
2.46
22.17
2.61
23.85
2.97
Effect of Jitter & Latency on Downloadspeed
Jitter
Latency
Speed(Mbps)
Effect of Jitter & Latency on Uploadspeed
Data utilization (Gb) by schools
School Type / Date
Elementary
Secondary
Avg. Traffic_Util..
2,877
4,277
3,499
3,563
4,662
20,204
52,340
39,346
29,665
47,709
Septe..
Octob..
Nove..
Dece..
Janua..
Top 7 applications
Application (ApplUsage)
Avg. Usage(GB)
646.1
675.9
367.0
343.8
263.5
448.9
107.6
Avg. Sessions
1,467,605
1,204,389
129,725
302,438
80,406
1,667,162
71,305
Google.Ser..
TikTok
Google.Ac..
YouTube
Apple.Store
QUIC
Apple.Servi..
Types of Applications consuming as % of subtotal per school
Application
Disney+
23.05
Google.Services
15.20
YouTube
14.06
STUN
13.70
QUIC
12.32
Google.Accounts
9.81
Steam
9.36
Netflix
7.47
MS.Windows.Update
5.90
Apple.Store
3.29
% of Subtotal
Traffic Utilization Vs Tempurature
Avg. Traffic_Utilization(..
Avg. Temp (°C)
1 Sep, 22
1 Oct, 22
1 Nov, 22
1 Dec, 22
1 Jan, 23
1 Feb, 23
Day of Date

Analysis of External Factor Weather

Apart from evaluating broadband technologies in schools, this report also delves into the impact of weather conditions on internet connectivity. It is vital to understand how adverse weather affects network performance to ensure reliable access to online resources and optimize the digital learning experience.

Although no direct relationship was found between weather conditions and network performance, an intriguing observation emerged. As temperatures rose, there was a noticeable decrease in internet connectivity usage in schools, and conversely, as temperatures dropped, usage increased. This pattern suggests that during warmer weather, individuals are more likely to spend time outdoors, resulting in fewer connected devices and a subsequent impact on internet usage in schools.

While the exact cause-effect relationship remains unclear, understanding this indirect correlation is valuable for optimizing resource allocation and infrastructure planning. By considering the influence of weather on usage patterns, educational institutions can adapt their strategies to ensure an efficient and reliable digital learning environment. Aligning infrastructure capacity with weather-induced fluctuations in internet usage can help address potential bandwidth constraints during periods of decreased connectivity demand. Ultimately, this insight aids in maximizing the effectiveness of broadband technologies in schools, supporting seamless digital learning experiences for students and educators.



A noteworthy observation was made regarding the relationship between temperature and device utilization. Specifically, as temperatures decrease, there is an observable increase in device utilization, while as temperatures increase, there is a corresponding decrease in device utilization.

Our analysis suggests that there is no significant relationship between Download & Upload speeds and Latency, Jitter, or Weather conditions. While these factors may impact overall network performance, they do not appear to have a direct influence on Download & Upload speeds. This finding underscores the importance of evaluating multiple broadband quality parameters to gain a comprehensive understanding of network performance and to identify potential areas for improvement.

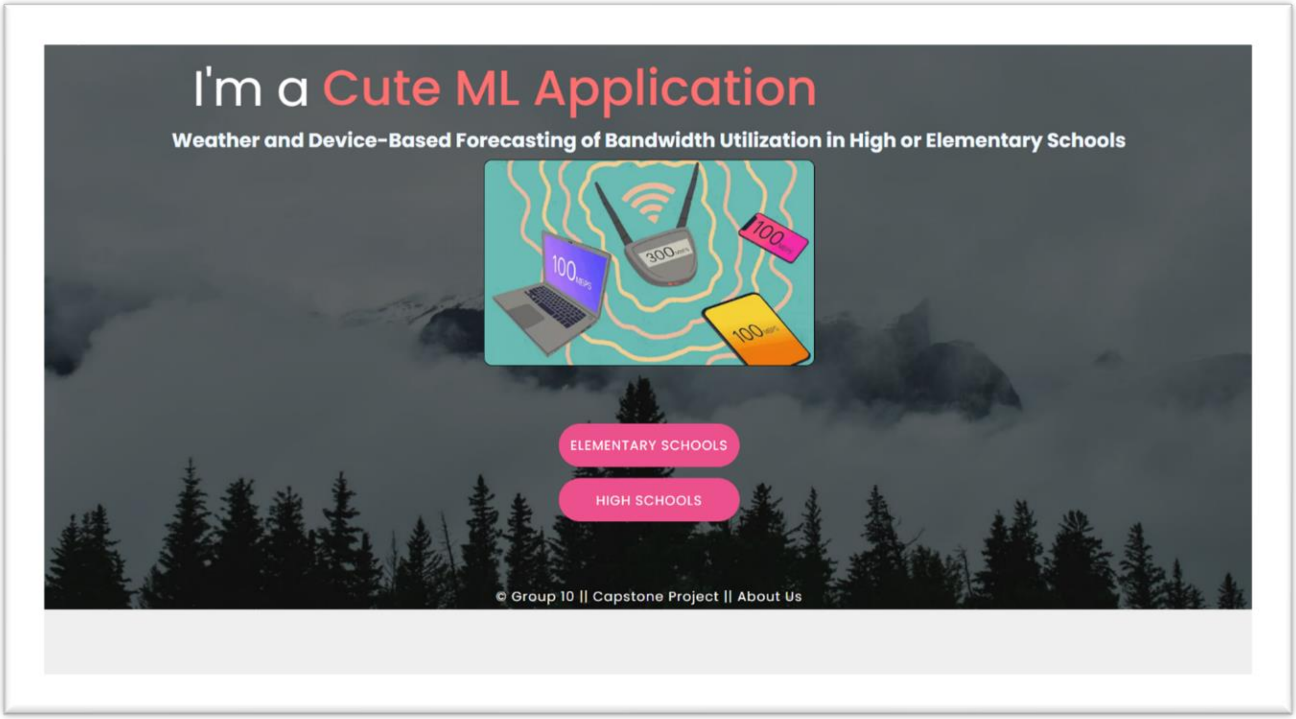
Model for prediction

In order to accurately predict device utilization in schools, we developed two distinct models: one for elementary schools and another for high schools. These models utilize weather data and projected device usage to generate forecasts for future device utilization. By analyzing historical device usage patterns and weather conditions, the models are able to identify trends and make informed predictions for future device utilization levels. This enables educational institutions to better allocate resources and optimize their network infrastructure to ensure a seamless digital learning experience for students and educators alike.

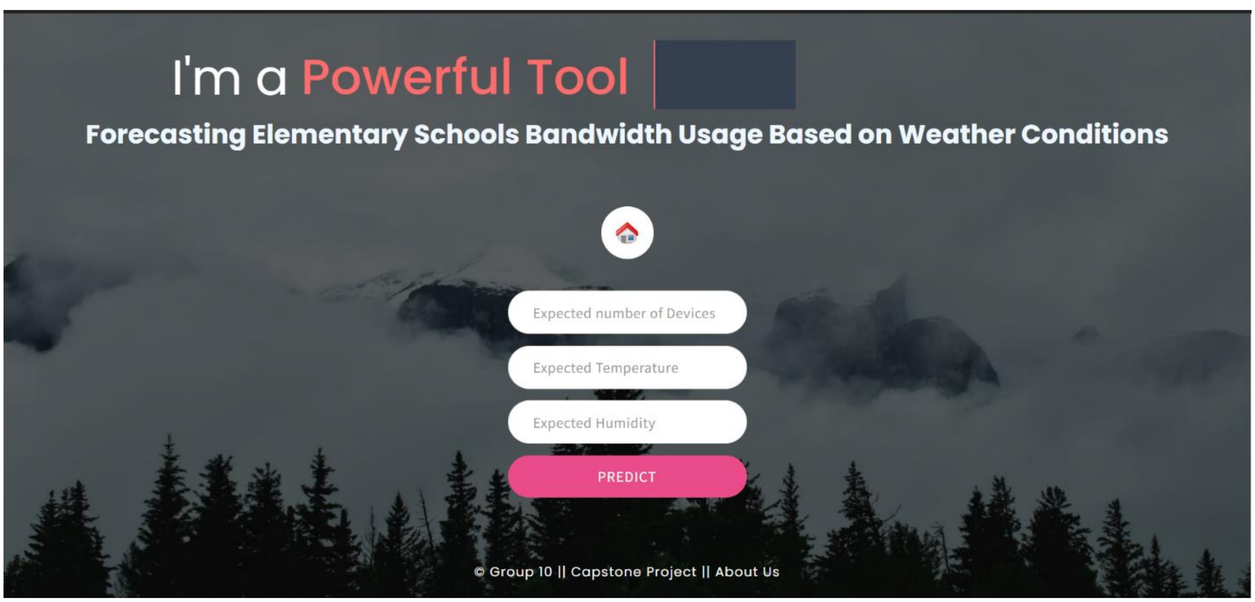
Model building: In the process of model building, multiple regression analysis is commonly employed. This involves using temperature and humidity, along with client data, as features, while data visualization is utilized as the target variable. Through this approach, it is possible to establish a statistical relationship between the independent variables (features) and the dependent variable (target) in order to make predictions and inform decision-making. By using multiple regression, we can assess the impact of each independent variable on the target variable, which can assist in understanding the underlying dynamics and relationships within the data.

	Clients	Device_utilization_in_percent	Temp (°C)	Rel Hum (%)
Date				
2022-09-01	135.8	6.5	21.2	66.1
2022-09-02	118.5	6.5	22.1	75.1
2022-09-03	55.2	6.5	23.9	77.0
2022-09-04	55.5	6.5	20.1	90.0
2022-09-05	74.0	6.5	20.2	86.8
...	...	...	...	...
2023-02-23	412.8	7.5	1.2	90.3
2023-02-24	[illegible]04.0	7.9	-3.1	60.5
2023-02-25	127.5	5.2	-1.9	79.1
2023-02-26	119.8	5.1	3.0	59.3
2023-02-27	535.0	8.7	-0.3	87.0

180 rows × 4 columns



The screenshot displays the user interface of our machine learning application, which allows for the prediction of device utilization for elementary schools. Users can simply click on the designated button, enter the relevant parameters such as the expected number of devices, temperature, and humidity, and click the "predict" button to obtain the model's forecast. This user-friendly interface simplifies the prediction process and enables efficient decision-making for optimizing resource allocation and infrastructure planning in educational institutions.



Evaluation of model

```
# Calculate MSE, R2 score, and MAE
from sklearn.metrics import mean_squared_error, r2_score, mean_absolute_error

mse = mean_squared_error(y_test,y_pred_test)
r2 = r2_score(y_test,y_pred_test)
mae = mean_absolute_error(y_test,y_pred_test)

# Calculate RMSE
rmse = np.sqrt(mse)

# Print the results
print("MSE:", mse)
print("R2 score:", r2)
print("MAE:", mae)
print("RMSE:", rmse)
```

```
MSE: 0.1340680587281506
R2 score: 0.9221330984531312
MAE: 0.28633249090019686
RMSE: 0.36615305369223755
```

The model was evaluated using several metrics, including the Mean Squared Error (MSE), the R-squared (R2) score, the Mean Absolute Error (MAE), and the Root Mean Squared Error (RMSE). The **MSE value of 0.1340680587281506** suggests that the model has a relatively low error rate in predicting the device utilization. The **R2 score of 0.9221330984531312** indicates that the model can explain a high percentage of the variance in the data. The **MAE value of 0.28633249090019686** represents the average absolute difference between the predicted and actual device utilization values. Finally, the **RMSE value of 0.36615305369223755** indicates the standard deviation of the errors made by the model in predicting the device utilization values. Overall, these evaluation metrics suggest that the model is performing well in predicting device utilization based on the given inputs.

INSIGHTS

To ensure the provision of optimal internet services to schools, several key factors need to be considered. First, high, and secondary schools require faster internet speeds compared to elementary schools. This is because high schools typically have a higher number of users and more complex online applications, such as video conferencing and virtual learning platforms.

Second, maintaining good quality of service parameters is essential. This involves ensuring that the internet connection is reliable, stable, and has sufficient bandwidth to accommodate the needs of the school. Additionally, uploads should be prioritized over downloads since this is more important for tasks such as video conferencing and online collaboration.

Third, it is common for elementary schools to experience higher latency and jitter compared to high schools. This is because elementary school internet usage is typically less demanding, and so the quality of service parameters are often not as high. However, packet losses should be minimized to ensure optimal connectivity.

Fourth, it is worth noting that download and upload speeds do not directly affect latency, jitter, or weather conditions. However, the type of device being used can be impacted by changes in weather.

Finally, social media applications such as Instagram, STUN, Steam, Netflix, and Google advertising are highly popular among high school students, while elementary school students tend to use YouTube, Disney+, and Netflix more frequently. These applications consume a significant amount of data, and it is important to ensure that the school's internet service can handle such traffic.

RECOMMENDATIONS

Based on the identified needs and challenges, several recommendations can be made to optimize internet services in elementary schools and High School:

Firstly, proper traffic management strategies should be implemented to ensure that internet bandwidth is being utilized efficiently. This may involve prioritizing certain types of traffic or restricting access to non-essential applications during peak usage periods.

Secondly, it is recommended to explore ways to reduce data usage by Google advertising, which can be a significant drain on internet bandwidth. One approach may involve implementing ad-blocking software or restricting access to certain ad servers.

Thirdly, negotiations with Internet Service Providers (ISPs) should be pursued to secure better pricing and service agreements that meet the needs of the school. This may involve exploring alternative service providers or leveraging the school's purchasing power to negotiate favorable terms.

Finally, the implementation of a Software-Defined Wide Area Network (SD WAN) can help optimize internet traffic and improve connectivity. SD WAN technology can intelligently route internet traffic, prioritize certain types of traffic, and dynamically adjust to changing network conditions to ensure optimal performance.

By implementing these recommendations, High and Elementary schools can improve the quality of their internet service, reduce costs, and ensure that students have access to the resources they need to succeed in a digital learning environment.

Conclusion

After conducting a thorough analysis of broadband technologies in schools in Southern West Ontario, several important conclusions have been drawn. First and foremost, effective traffic management strategies must be implemented in elementary schools. Prioritizing educational applications and reducing the usage of non-essential applications, such as Google advertising, STEAM, and TikTok, will ensure the efficient utilization of network resources for educational purposes.

Secondly, exploring ways to minimize data consumption by specific applications is recommended. This can help alleviate network congestion and improve overall connectivity for educational activities.

Furthermore, schools should consider negotiating with Internet Service Providers (ISPs) for better pricing and service agreements. Collective demand can enable educational institutions to secure more favorable terms, ensuring cost-effective and reliable broadband connectivity.

Lastly, implementing SD-WAN technology in elementary schools is recommended. SD-WAN has demonstrated successful performance in high schools, and its adoption in elementary schools can facilitate efficient traffic routing, load balancing, and prioritization of critical applications. This will result in improved network performance and user experience.

In conclusion, the implementation of proper traffic management, the reduction of data usage by specific applications, negotiating with ISPs for better pricing, and considering the implementation of SD-WAN technology can optimize broadband technology utilization in Southern West Ontario schools. These measures will enhance connectivity, supporting an enriched digital learning environment for students and educators across all educational levels.

References and links

References:

- http://cw-e.ca/about.html
- https://www.speedtest.net/

Git Hub Link:

https://github.com/AnilKakkar76/CapstoneProject_CW-E