Undergraduate Final Report: How Are You Served By the Internet?

Alex Wang - 18tw7@queensu.ca

Yuehan Qi - 18yq36@queensu.ca

Peiyang Huang - 18ph18@queensu.ca

Course Project

CISC 499

Advanced Undergraduate Project

April 9, 2023

Contents

Abstract

This project offers a web application analyzing Canadian broadband distribution and related social factors. Featuring an interactive map and user-friendly dashboards, it provides valuable insights for policymakers, ISPs, and related companies, aiding informed decision-making and future planning.

1 Introduction

In this project, we delve into the exploration, visualization, analysis, and envisioning of internet service provision in Canada, utilizing data from the Open Government portal of National Broadband Data. We have developed a map-centered interactive web application to showcase the national broadband data, while also investigating potential social factors that influence internet coverage across various regions of Canada. Our goal is to offer valuable insights on broadband investment to ensure efficiency for the government. The data visualization presented in this project aims to illustrate the internet usage penetration across different Canadian provinces, demonstrate the availability of cellular services in both urban and rural areas, and highlight the relative level of LTE coverage in major population centers and significant roadways. Through this comprehensive analysis, we seek to provide a clearer understanding of the current state of internet service provision in Canada and contribute to future improvements.

2 Motivation

The motivation behind our project stems from the desire to examine the persistent disparities in access and quality of broadband connectivity across various regions of Canada. Despite the widespread availability of broadband connectivity in the country, significant disparities persist between urban and rural areas, as well as between different regions. Our research aims to explore the potential social factors that contribute to these disparities, such as household income and education levels of residents in the area, and to investigate the relationship between these factors and economic growth. By analyzing the national broadband data, we aspire to pinpoint areas where investment in broadband infrastructure could yield the most significant impact, offering valuable advice to the government on efficient broadband investment strategies. Ultimately, our objective is to empower users to make well-informed decisions regarding broadband connectivity in Canada through our comprehensive data visualization. The dataset is the official national broadband data from the Government of Canada [1] [2].

3 Broadband Dashboard

3.1 Overview

Our webpage layout features a left and right double-page separation for chart representation, with added graphs such as bar charts and pie charts for data display. We included switch buttons on pages 1, 2, and 3 in the upper right corner of the main framework, enabling users to easily switch between pages and import table and map data. The table page facilitates user comparisons and analysis alongside the map on page 3. Users can view data differences between various projects, provinces, or regions, and the heat map on page 3 utilizes the Google Maps API interface for coverage area visualization. This layout allows for seamless data and map comparison, aiding in correlation analysis. Additionally, we have incorporated features such as data download, redo operations, and chart screenshots for each chart type (pie chart, line chart, and bar chart).

3.2 Methodology

1. ***Data Processing Section***

   For basic data processing, the approach employed numpy and pandas for handling data packets and algorithms. Various formats such as txt and GPKG were unified and standardized into CSV files. Additionally, geographic location and network speed tags were converted into standardized CSV files. Challenges arose during the grouping process, for instance, in the NBD-ROADS_CSV file, there is an entry called NGDUID containing names of large road sections and labels of smaller road sections. Integrating this data would result in a data size far exceeding the x and y-axis displayable for users. The solution was to divide the data by 1000, effectively reducing the order of magnitude.

2. ***Framework and Front-end Section***

   A framework was built using JavaScript's web user interface in collaboration with Node.js, NPM, and Vue. A script based on the Node.js platform was created for the production environment, with the project primarily focusing on the front-end environment. Version-related issues were encountered, as the NPM environment configuration frequently produced errors when coding on different computers in varying environments. To resolve these errors, the version detection script was modified during the framework building process to adapt to the development environment and webpack configuration files were introduced to facilitate packaging and optimizing front-end application resources.

   For the user interface, the JavaScript open-source visualization chart library Echarts was chosen for designing visualizations, and Vue.js was used to construct user pages. In this section, the environment and dependency libraries for the Vue.js application were configured, necessary libraries and components were introduced, and global properties were set for their use throughout the entire application. Echarts' open-source resources were utilized to guide user interface development, and a sidebar was incorporated on the page for convenient content display. The toggleCollapses method was employed to switch between folding and unfolding the sidebar.

Vue Router and Element UI component libraries were utilized to implement page routing via Vue Router and sidebars through the Element UI menu component. Furthermore, third-party libraries such as Axios and Echarts were employed for functionalities like sending network requests and drawing charts. Vue 2.0's desktop component library Element-UI was used to implement some components, and page self-adaptability and chart-to-box adaptability were optimized using el col and Element UI responsive layout. On pages 1 and 2, the chart was divided into six small components for import, rather than directly writing them on the page, to facilitate better management and design.

3.3 Result

1. ***The First Page***

   On the first page of the user interface, a left-right separated format was designed.

   The left side of the first page features a line chart displaying the network speed gap and peak values across different regions. Interaction-wise, buttons were incorporated to allow users to click on various internet speed ranges, facilitating the folding or expansion of lines representing different speeds. A draggable bottom border was also designed to enable users to easily browse network speeds in areas varying with ID. The jQuery library was utilized for asynchronously fetching JSON data, leveraging jQuery's get() method and a local server JSON file to efficiently obtain data.

   On the bottom left, a pie chart was designed to showcase the financial support received by different regions, enabling users to compare funding or the number of funded projects across regions.

   On the right side, a Canadian population distribution map was created to compare with the heatmap on page 3 and analyze the correlation between population density and project coverage. A draggable sliding button on the right allows filtering provinces and regions based on population distribution levels.

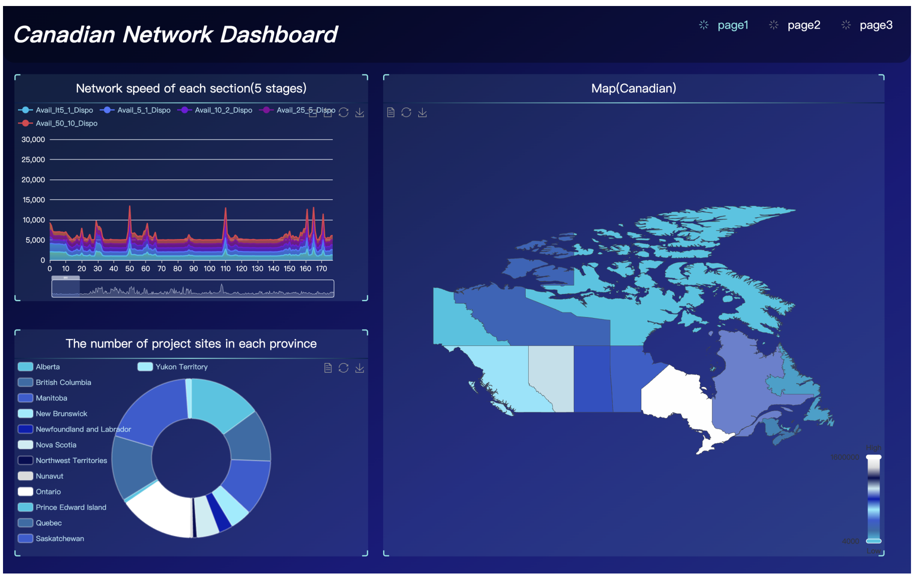


Figure 1: Page 1 of the dashboard

2. ***The Second Page***

For the second page of the user interface, CSS was employed to achieve dynamic gradient rendering of the background. Gradient background and border styles were used to enhance the page's aesthetics, with the scoped attribute minimizing the impact on other components.

On the left side of the second page, a bar chart was designed, displaying eight different types of broadband access technologies and usage in thirteen Canadian provinces/regions. Each technology was represented by a differently colored bar, grouped by province/region. Bar height indicates the number of broadband access points in each area. By hovering the mouse over the bar charts, users can view detailed numbers and data.

In the upper right, a bar chart was designed to showcase the density of private housing in Canadian provinces, divided by blocks based on Canadian government database information.

In the lower right corner, a pie chart was designed to display the number of affected blocks, helping users understand that many sparsely populated provinces have a large number of blocks not included in the database due to the lack of inhabitants; provinces with more funding may have a corresponding increase in the number of occupied blocks.

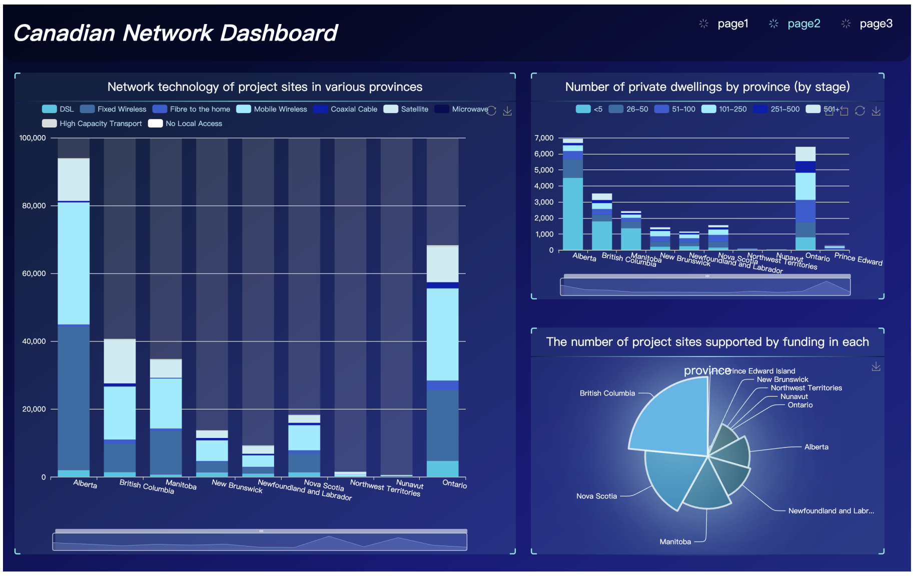


Figure 2: Page 2 of the dashboard

4 Interactive Map

4.1 Overview

The primary goal is to create an interactive heatmap for visualizing geospatial data. Heatmaps are useful for understanding the density and distribution of data points across a geographic area. This implementation utilizes Google Maps API for rendering the map and heatmap layer, along with jQuery for loading and parsing CSV data. Additionally, tree and search algorithms are employed for data processing and manipulation. It provides a comprehensive overview of the methodology and results of the map, aiming to serve as a foundation for future development and improvement.

4.2 Methodology

1. ***Initializing the Google Maps and Heatmap Layer***

   The first step in creating the interactive heatmap is initializing a Google Maps instance with the specified zoom level and center point. A **div** element with a unique identifier is created within the HTML file to serve as the map container. In the JavaScript file, a new Google Maps instance is created, and the center point and zoom level are defined.

Once the Google Maps instance is set up, a heatmap layer is created using Google Maps' visualization library. The heatmap layer is initially configured with a blank data set and is added to the map instance. As the data is loaded and processed, it will be used to update the heatmap layer.

2. ***Loading and Parsing CSV Sata***

   The next step is to load the CSV data that will be used to populate the heatmap. jQuery's **ajax()** method is employed to send an HTTP request for the CSV file. When the request is successful, the data is parsed by splitting it into rows and then columns. Each row represents a data point, and each column contains the latitude and longitude information.

   The parsed data is stored in an array of objects, with each object representing a data point. These objects will later be used to create LatLng objects for the heatmap layer.

3. ***Data Preprocessing and Manipulation***

   To process the CSV data, permutation and tree algorithms are used. The permutation algorithm generates all possible arrangements of the data points, which is helpful when dealing with large data sets and complex relationships between data points. The tree algorithm is used to structure the data into a hierarchical format, allowing for efficient search and manipulation.

   Once the data is processed, it is converted into LatLng objects, which are used by the heatmap layer for visualization. The data is stored in an array, with each element being a LatLng object representing a data point.

4. ***Customizing the Heatmap***

   To provide users with customization options, functions are implemented to update the heatmap's visibility, color gradient, point radius, and opacity based on user input. Event listeners are added to checkboxes and other input elements in the HTML file, which trigger corresponding functions in the JavaScript file when their values are changed.

   For example, when a user selects a checkbox to toggle the visibility of a specific heatmap layer, the function updates the 'map' property of the heatmap layer accordingly. If the checkbox is checked, the heatmap layer is associated with the map instance, making it visible. If the checkbox is unchecked, the heatmap layer's 'map' property is set to 'null', hiding it from the map.

   Additional customization options, such as changing the color gradient, adjusting the point radius, and modifying the opacity, are implemented using similar methods. These functions allow users to tailor the heatmap to their preferences and better understand the geospatial data being visualized.

   By following these steps, an interactive heatmap is created that effectively visualizes geospatial data and provides customization options for users to explore the data further.

4.3 Result

1. ***Webpage Overview***

   Below figure presents a preview of our interactive map. The section on the left displays a map of Canada, which is rendered using the Google Maps API. By interacting with the map, users can zoom in or out to focus on specific regions or gain a broader perspective.

   The section on the right is a government project or grant for the implementation of broadband network services. Users can click on the options to see the coverage area of the project on the map.

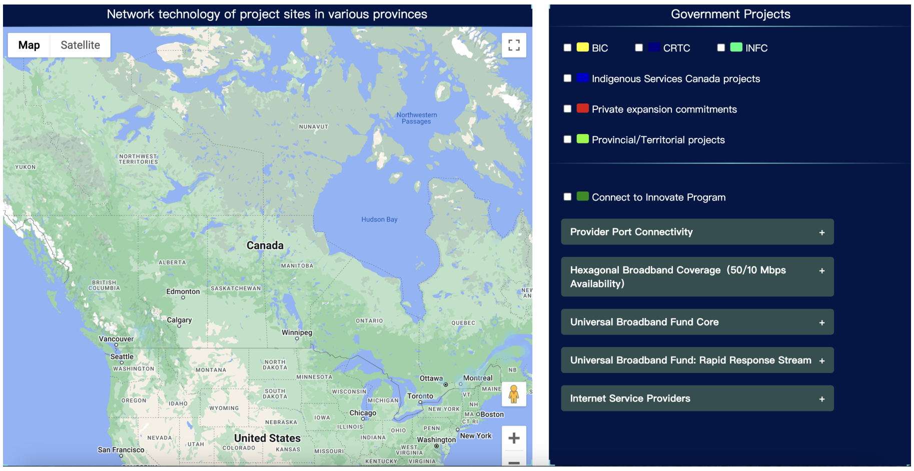
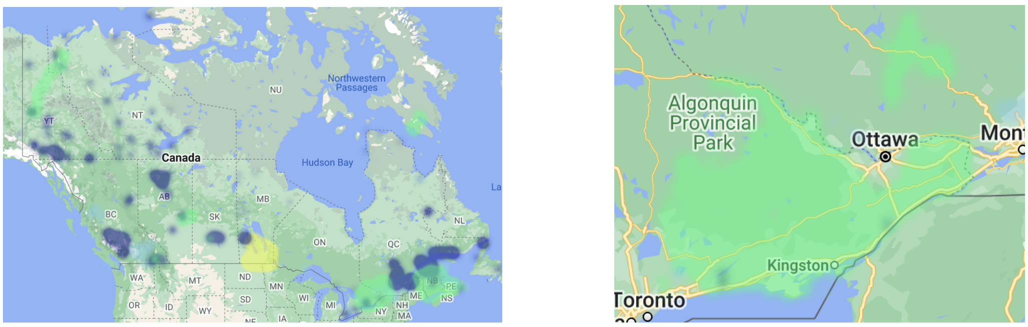


Figure 3: Preview of the interactive map

2. ***Government Project***

   When we check the boxes for CIB (The Canada Infrastructure Bank), CRTC (Canadian Radio-television and Telecommunications Commission), and INFC (Infrastructure Canada), we can see the coverage of these three institutions across the country. checkbox, Figure A below shows the coverage of the funded projects of these three institutions across the country. The three different colours are highlighted to give government workers a clear view of the specific situation they need. Figure B shows a zoomed in map to see the specific coverage of areas around Ottawa to allow for a more precise view of funding in some rural areas.



(a) National preview

(b) Specific view near Ottawa

Figure 4: Project coverage: CIB, CRTC, INFC

3. ***50/10 Mbps or Higher Speeds Regions Demo***

   The interactive map offers a valuable overview of broadband service availability, providing 50/10 Mbps or higher speeds across different regions in Canada. The map employs a hexagonal representation of areas based on in-depth coverage data from Internet Service Providers (ISPs), as reported to the CRTC and ISED. It also takes into account the Pseudo-household Demographic Distribution from the 2016 Canadian Census[3].

   The map is divided into four distinct categories, each representing a different degree of broadband accessibility among households base on national broadband data information from Statistic Canada[3]:

   High access areas (75% to 100%): These areas exhibit the greatest level of broadband coverage, where more than 75% and up to 100% of households have access to broadband services offering 50/10 Mbps or higher speeds. Such regions typically possess well-established infrastructure and a higher density of ISPs.

Moderate access areas (50% to 75%): In these regions, over 50% and up to 75% of households have access to broadband services offering 50/10 Mbps or higher speeds. These areas may include a combination of urban and rural locations, with some parts enjoying better connectivity than others.

Lower access areas (25% to 50%): These areas represent regions where over 25% and up to 50% of households have access to broadband services offering 50/10 Mbps or higher speeds. The infrastructure in these areas may be less developed, and ISPs might not have extensively expanded their services.

Minimal access areas (0% to 25%): These regions have the lowest level of broadband coverage, where over 0% and up to 25% of households have access to broadband services offering 50/10 Mbps or higher speeds. Such areas are often remote or rural locations, where the development of broadband infrastructure faces various challenges.

By examining the map, policymakers and ISPs can gain a better understanding of broadband access throughout the country. This information can help guide decisions related to infrastructure investments, expansion plans, and strategies to improve internet access for all Canadians.

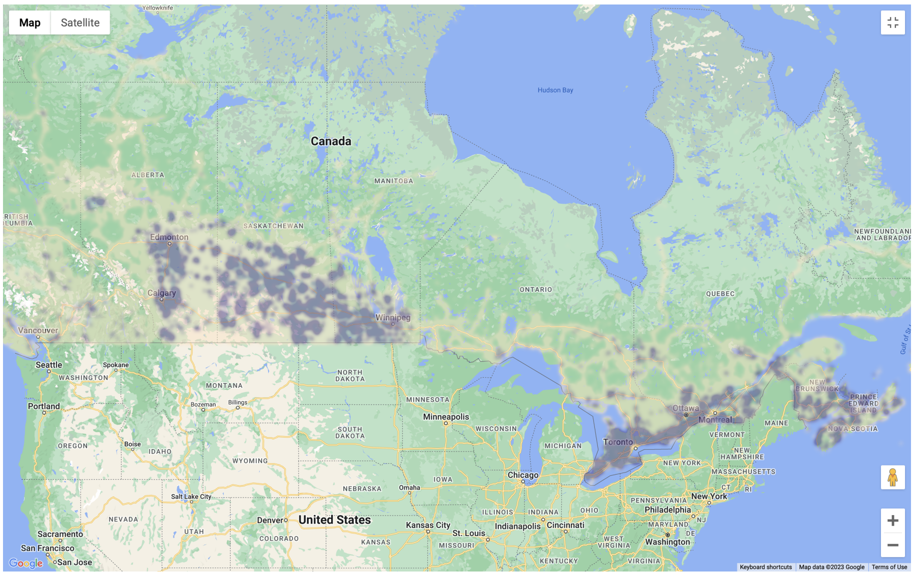


Figure 5: Canada's Broadband Access: Minimal and Moderate Coverage Areas

4. ***Comparing Broadband Technologies: FTTH, Mobile Wireless, and Satellite Coverage***

The map showcases the different technologies provided by Internet Service Providers (ISPs) across Canada.

It incorporates multiple layers representing the availability and reach of broadband services, such as Fibre to the Home (FTTH), Mobile Wireless, and Satellite connections. By examining the percentage of households with access to various levels of internet speeds, users can better understand the extent to which different regions of Canada are connected. Moreover, the map highlights areas with minimal, moderate, and extensive access to broadband services, shedding light on the existing digital divide and guiding policymakers in making informed decisions to improve internet accessibility.

Coverage Demonstration:

The "Fibre to the Home" coverage map offers an in-depth view of the areas where high-speed fibre optic connections are available directly to households. These connections offer superior speed and reliability compared to other broadband technologies. The map highlights areas with widespread FTTH coverage, allowing users to identify regions where this cutting-edge technology is accessible. It also helps policymakers and ISPs recognize areas that may require further investment in fibre infrastructure to bridge the digital divide and promote equal access to high-quality internet services.

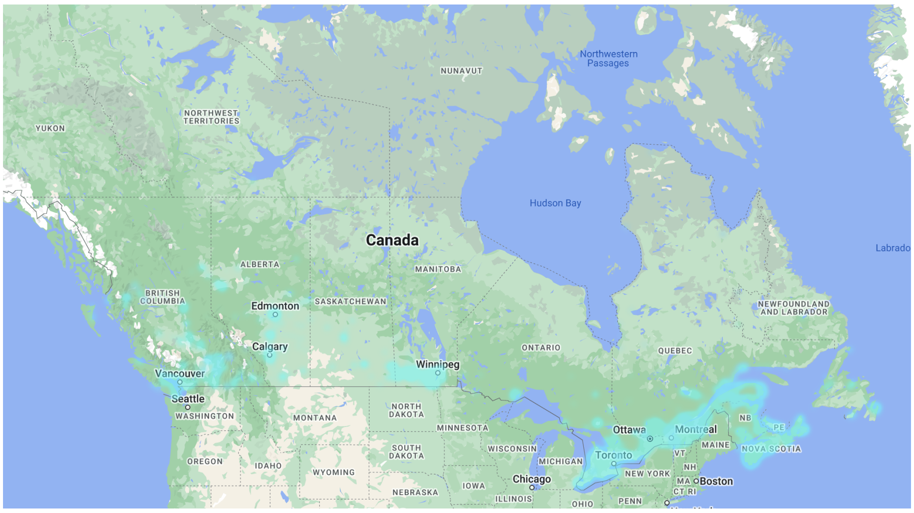


Figure 6: Fibre to the Home (FTTH) Coverage Map

The "Mobile Wireless" coverage map displays the extent of mobile broadband services across Canada. This map highlights the regions where users can access internet services through their smartphones, tablets, and other mobile devices. By showcasing the availability of mobile wireless coverage, this map helps users understand the reach of this technology and its role in providing internet connectivity, especially in areas where fixed-line broadband infrastructure is limited or not available. This information can also be valuable for mobile service providers and policymakers as they work to expand and improve mobile broadband coverage in underserved areas.

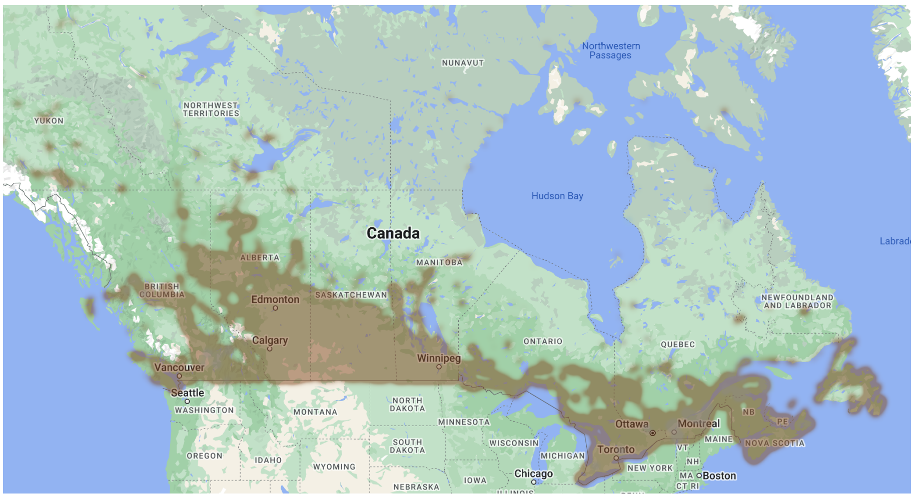


Figure 7: Mobile Wireless Coverage Map

The "Satellite" coverage map demonstrates the regions where internet services are provided through satellite connections. Satellite technology plays a crucial role in bringing internet access to remote and rural areas, where traditional broadband infrastructure is often limited or entirely unavailable. By illustrating the distribution of satellite coverage, this map helps users understand the geographical reach of this technology and its importance in connecting underserved communities. It also enables policymakers and ISPs to identify areas that may benefit from further investment in satellite broadband infrastructure, ensuring that all Canadians have access to reliable internet services.

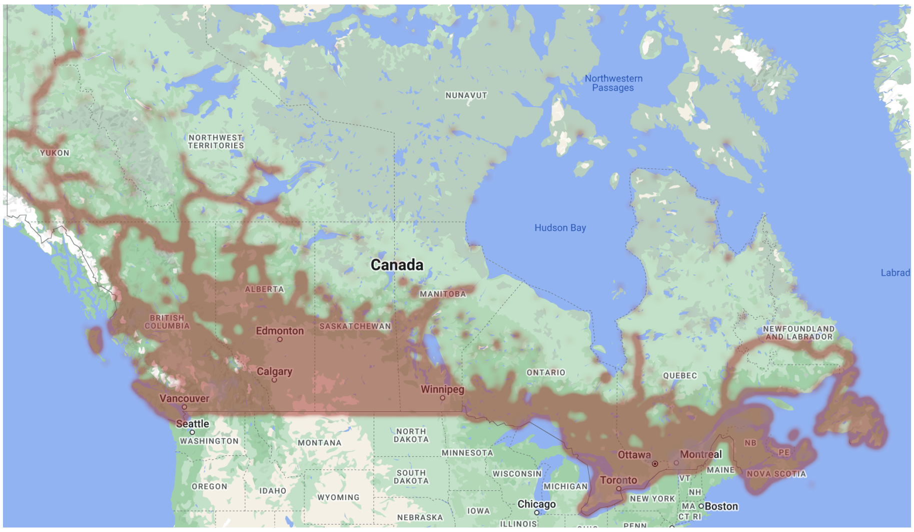


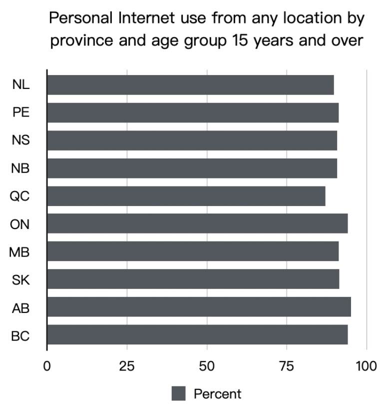
Figure 8: Satellite Coverage Map

5 Findings

5.1 Internet Usage in Canada

1. ***Regional and Age Group Differences***

   In 2020, 92.3% of Canadians aged 15 years and over used the internet from any location for personal purposes. The highest rates of personal internet use were reported in Alberta (95.2%) and British Columbia (94.2%), while the lowest rates were reported in Quebec (87.1%) and Newfoundland and Labrador (89.8%). When examining personal internet use by age group, the highest rates of internet use were among individuals aged 15-44, with 98.2% of individuals aged 15-24, 97.1% of individuals aged 25-34, and 94.3% of individuals aged 35-44 reporting personal internet use. The rates of personal internet use decreased with increasing age, with 81.2% of individuals aged 65 and over reporting personal internet use [4].



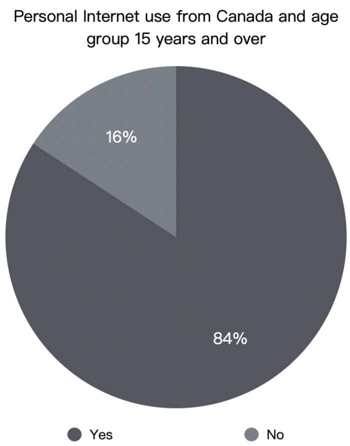


Figure 9: Personal internet use from age 15 years and over

5.2 Intensity of Internet, Video Streaming, and Video Gaming Services Use

1. ***Age Groups and Education Levels***

   The data from the Canadian Internet Use Survey in 2020 suggests that the intensity of use of internet, video streaming services, and video gaming services varied across age groups and education levels among individuals aged 15 years or over in Canada [5]. Younger age groups and individuals with higher education levels tend to use these services more frequently compared to older age groups and those with lower education levels. Additionally, individuals who spent 20 hours or more per week on the internet, video streaming services, or video gaming services may be at increased risk for negative effects such as addiction, decreased social interaction, and decreased physical activity.

2. ***Implications for Policymakers and Educators***

   These findings highlight the importance of promoting digital literacy and access to individuals of all ages and education levels. Policymakers and educators can use these findings to design interventions that address the unique needs of different demographic groups. For example, digital literacy programs can be developed and targeted to individuals with lower education levels, and initiatives to promote physical activity and social interaction can be developed to address the potential negative effects of high levels of internet, video streaming, or video gaming use.

5.3 Internet Access and Family Income

1. ***Internet Access in Different Income Quartiles***

   For the 2020 data, the lowest quartile is defined as less than or equal to $52,203, the second quartile is from $52,204 to $92,485, the third quartile is from $92,486 to $146,559, and the highest quartile is $146,560 or higher [6]. The graph shows the percentage of individuals in different age groups and family income quartiles who access the internet at various locations. The data highlights that the majority of people in all income quartiles use the internet at home, with over 75% of individuals in each quartile reporting this as a location for internet access. Additionally, the highest income quartile has a higher percentage of individuals accessing the internet at work and at someone else's home, while the lowest income quartile has a higher percentage of individuals accessing the internet at a public library or another public location.

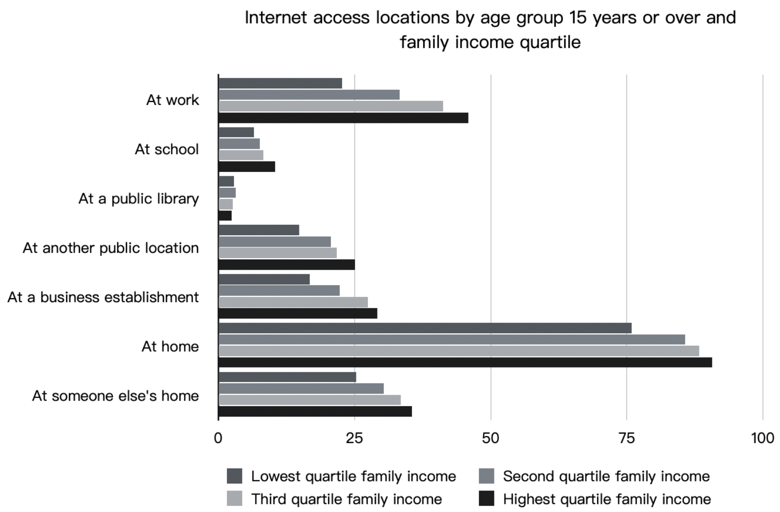


Figure 10: Internet access locations bar chart

2. ***Policy Implications for Internet Access***

   This information can be useful for policymakers as it shows that efforts to ensure equal access to the internet need to focus not only on affordability and availability of services but also on ensuring access in public spaces, such as libraries and community centers, which may be important for individuals in lower income brackets who do not have access to the internet at home or work. Policymakers can use this information to guide the development of programs and policies aimed at increasing access to the internet, especially for those in lower income quartiles.

5.4 Smartphone Usage and Habits

1. ***Policy Implications for Internet Access***

   Below table provides important insights into how different age groups use smartphones for personal use, as well as selected smartphone habits. One key finding is that a vast majority of individuals aged 15 and over in Canada have a smartphone for personal use, with the highest percentage found in the 15 to 24-year-old age group at 96.3%. Additionally, the data shows that individuals in younger age groups tend to use their smartphones more frequently and in different contexts compared to older age groups. For example, a higher percentage of individuals in the 15 to 24-year-old age group check their smartphones at least every 30 minutes, use their smartphones while watching television, and use their smartphones as the first and last activity of the day.

Table 1: Smartphone Usage Habits by Age Group

	Age Group			
Smartphone Habits	**15-24**	**25-44**	**45-64**	**65+**
Have a smartphone for personal use	96.3%	96.5%	86.7%	54.1%
Check the smartphone at least every 30 minutes	70.6%	59.8%	35.0%	12.3%
Before going to sleep, the last thing is to check the smartphone	75.4%	68.6%	44.4%	18.4%
Use the smartphone while watching television	60.3%	63.8%	42.2%	19.1%
Use the smartphone while eating dinner with others	20.9%	20.6%	8.5%	3.0%
After waking up, the first thing you do is check your smartphone	75.6%	68.7%	47.6%	22.4%

2. ***Implications for Healthy Smartphone Habits***

   These findings have important implications for individuals, families, and society as a whole. While smartphones can provide many benefits such as staying connected with loved ones and accessing important information, excessive use can also have negative effects on mental health, social interactions, and sleep patterns. Therefore, it is important for individuals and families to be aware of their smartphone usage patterns and take steps to minimize excessive use. This can include setting limits on phone usage, establishing smartphone-free zones, and engaging in activities that do not involve smartphones.

   Policymakers and healthcare professionals can also use this information to develop educational programs and interventions aimed at promoting healthy smartphone habits among individuals of all ages. For example, schools and community organizations can provide workshops on digital literacy and responsible smartphone use, while healthcare professionals can provide counseling and resources for individuals struggling with excessive smartphone use.

5.5 Conclusion

In summary, our analysis of the Canadian Internet Use Survey data has revealed significant variations in internet usage and smartphone habits among different demographic groups. These findings highlight the importance of promoting digital literacy and access to all Canadians.

Our interactive map and dashboard provide a user-friendly platform for policymakers, educators, and stakeholders to visualize these findings and identify areas for targeted interventions. By addressing the unique needs of different demographic groups, we can ensure equitable access to digital services and foster a more inclusive digital landscape. The project will also facilitate ongoing monitoring of trends and evaluation of the effectiveness of implemented interventions, allowing for data-driven decision-making.

6 Map-Centered Webpage

Our team has developed an interactive web application (`https://jojo0117.github.io/Undergrad_Project/`) that provides users with comprehensive information on the Canadian national broadband distribution and its related social factors. The user-friendly application features a map with multiple layers, allowing users to filter and view different layouts for each Canadian province. And it is an embedded hyperlink that leads directly to the interactive map and dashboard (`http://sdk.gamesyoua.com/payment/images/index/index.html#/Info/page1`). Furthermore, the website includes several dashboards showcasing various aspects of each province, such as network technology at project sites, the number of private dwellings, and the number of project sites supported by funding.

The process of uploading the visual map and broadband dashboard pages from a local environment to the server involved the use of aaPanel, a user-friendly control panel that streamlines server management tasks such as deploying applications, configuring databases, and managing files. By utilizing aaPanel, we were able to efficiently deploy the server without needing extensive technical expertise.

To initiate the process, the "dils" file from the project was uploaded to the preconfigured domain folder using aaPanel's file manager. After successfully uploading the file, the application could be accessed through the purchased domain name. The online access to the dashboard and map enables users to easily view and share these resources with other technical professionals, enhancing collaboration and knowledge exchange. It's crucial to adhere to security and performance best practices when configuring and deploying the server. Regular backups and updates must also be executed to maintain smooth and secure operation of the application.

In order to transform the visual map and broadband dashboard pages into a formal report, we carefully extracted relevant data and visualizations from the application, ensuring that the content was presented clearly and effectively. By integrating this information into the report, we created a comprehensive and accessible resource that reflects the project's findings and implications for stakeholders interested in understanding the current state of broadband distribution in Canada and its societal impact.

The web application offers a thorough overview of our findings and their implications for stakeholders, presenting a clear representation of broadband distribution in Canada. Designed to be accessible to a broad audience, including policymakers, internet service providers, and related companies, this application serves as a valuable resource for anyone interested in understanding the current state of Canadian broadband distribution and its societal impact.

7 Impact

7.1 Insights for Stakeholders

The impact of our project on the real world is multifaceted, as it can provide valuable insights for stakeholders involved in broadband infrastructure development and contribute to bridging the digital divide in Canada.

1. ***Policymaker***

One example of the real-world impact of our project can be seen in the identification of rural areas with inadequate broadband connectivity. Our data visualization could be used by policymakers to prioritize investment in broadband infrastructure in these underserved areas, ultimately promoting economic growth and social inclusion. For instance, in 2019, the Canadian Radio-television and Telecommunications Commission (CRTC) announced a $750 million fund to improve broadband access in rural and remote areas of Canada [7]. By providing a comprehensive visualization of the current state of broadband connectivity in the country, our project can help policymakers identify areas that require immediate attention and allocate resources more efficiently.

Our data visualization can help policymakers identify specific regions where the digital divide is more prominent, enabling them to design targeted policies and initiatives to address these gaps. For example, in the Canadian province of Newfoundland and Labrador, rural areas have historically struggled with limited internet connectivity. Our project can help policymakers in such provinces to better understand the disparities in access and quality, allowing them to implement more effective solutions. A historic collaboration between the Canadian Government and the Newfoundland and Labrador Government will invest up to $136 million to connect all remaining rural households in Newfoundland and Labrador to high-speed internet. The partnership aims to achieve the national target of connecting 98% of Canadians by 2026 and 100% by 2030 [8].

2. ***Internet service providers(ISPs)***

   Our project's impact extends to internet service providers (ISPs) who can use the insights derived from our data visualization to strategically expand their networks and cater to regions with high demand for improved connectivity. For example, Xplornet Communications Inc., a rural broadband provider, has been working to improve internet access for Canadians living in rural areas [9]. Our project could aid ISPs like Xplornet in identifying potential areas for expansion and better understanding the needs of their target customers.

   Moreover, our project can help ISPs identify potential areas where collaboration with other ISPs or public-private partnerships could be beneficial in expanding broadband infrastructure. For instance, the Connecting British Columbia program, funded by the provincial government, encourages ISPs to collaborate on projects that improve internet access in underserved communities [10]. Our data visualization can provide ISPs with valuable information about regions where such collaborative efforts could have the most significant impact.

7.2 Multidimensional Benefits

1. ***Education***

   The interactive web application developed in this project enables policymakers to visualize the disparities in internet access in different regions of Canada. This information can aid in making informed decisions for investments in broadband connectivity for underprivileged areas that have schools, which in turn will improve students' access to online educational resources, e-learning platforms, and remote tutoring services.

2. ***Healthcare***

   The project's data visualization helps identify areas with limited internet connectivity, which can be critical in making decisions to improve telecommunication services in remote regions with people living in those areas. Enhancing internet connectivity in these areas will strengthen telehealth services, enabling healthcare providers to offer remote consultations, diagnoses, and monitoring for patients in far-flung communities.

3. ***Economic growth***

   By analyzing the broadband data and highlighting regions with inadequate internet access, this project can guide the government and ISPs in strategically investing in broadband infrastructure. Improved internet connectivity can improve economic development by attracting new businesses, promoting entrepreneurship, and creating job opportunities in underdeveloped areas.

4. ***Emergency services***

   The project's interactive web application showcases the areas with limited broadband connectivity, which can be crucial for planning improvements in communication networks for emergency services. By enhancing internet access in these regions, emergency response times can be reduced, and disaster management can be more effectively coordinated, ultimately saving lives and property.

8 Challenge

This section discusses the various challenges we faced during the project, such as data preprocessing, time management, and handling geospatial data, along with the solutions employed to overcome these obstacles.

8.1 Data Preprocessing

One significant challenge we encountered was working with a dataset containing information about internet service providers and their coverage areas. Some entries had missing values, while others had inconsistent naming conventions. To ensure accurate and meaningful results, we had to consolidate and clean the data before proceeding with the analysis. This experience emphasized the importance of preprocessing data in any data-driven project.

8.2 Time Management and Prioritization

Effective time management was essential to the success of the project. One instance where we had to make a crucial decision was when we had to choose between incorporating more advanced features in the dashboard or focusing on refining the existing visualizations. We opted for the latter, ensuring that our core visualizations were polished and effectively conveyed the information. This experience highlighted the importance of prioritization in achieving project objectives and maintaining a healthy work-life balance.

8.3 Handling Geospatial Data and Performance

One of the challenges we faced was handling large amounts of geospatial data while maintaining the map's performance and interactivity. To address this issue, we identified bottlenecks that were slowing things down and utilized techniques like quadtree and R-tree data structures to split the data into smaller parts. This significantly improved the map's performance. We also grouped data points that were close together, further enhancing the map's efficiency and user-friendliness. Ultimately, by tackling this challenge, we built a more effective tool for visualizing and understanding spatial patterns.

By overcoming these challenges, we were able to deliver a high-quality project that effectively addressed the needs of our stakeholders, providing valuable insights and tools for policymakers, ISPs, and the general public.

9 Conclusion

In conclusion, this project has successfully provided a comprehensive analysis of the broadband distribution in Canada and its impact on various societal factors. Through the development of an interactive map and broadband dashboard, we have delivered a user-friendly, accessible platform that allows users to easily explore and understand the state of broadband connectivity across the country. The visualizations and data presented in the report serve as valuable resources for a wide range of stakeholders, including policymakers, internet service providers, and related companies.

Our findings indicate that while there has been progress in expanding broadband coverage in Canada, disparities in access and usage still exist across provinces, age groups, income levels, and educational backgrounds. These insights emphasize the importance of continued investment in digital infrastructure and the development of targeted interventions to address the unique needs of different demographic groups.

Throughout the project, we have overcome various challenges, including data preprocessing, effective time management, and optimizing the performance of our geospatial visualizations. These experiences have not only contributed to the successful completion of the project but have also provided valuable learnings that can be applied to future endeavors.

As broadband connectivity continues to play a critical role in modern society, it is essential for ongoing research and monitoring of its distribution and impact. We believe that our project serves as a strong foundation for future work in this field, and we hope that it will contribute to informed decision-making and the development of policies aimed at promoting equitable access to broadband services for all Canadians.

References

[1] Industry Canada. "National broadband data." (2016), [Online]. Available: `https://open.canada.ca/data/en/dataset/00a331db-121b-445d-b119-35dbbe3eedd9`.

[2] Innovation, Science and Economic Development Canada. "Hexagonal grid of canada." (2018), [Online]. Available: `https://open.canada.ca/data/en/dataset/4129e42c-bfa6-40f1-9b2a-19dc04136bb4`.

[3] Government of Canada. "Science and economic development canada - national broadband data information." Accessed: 2023-04-05. (2022), [Online]. Available: `https://ised-isde.canada.ca/site/high-speed-internet-canada/en/universal-broadband-fund/national-broadband-data-information`.

[4] Statistics Canada. "Personal internet use from any location by province and age group." Accessed: 2023-03-01. (2021), [Online]. Available: `https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2210013501`.

[5] Statistics Canada. "Intensity of use of internet, video streaming services and video gaming services by gender, age group and highest certificate, diploma or degree completed." Accessed: 2023-03-01. (2021), [Online]. Available: `https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2210013601`.

[6] Statistics Canada. "Internet access locations by age group and family income quartile." Accessed: 2023-03-01. (2021), [Online]. Available: `https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2210014401`.

[7] CRTC. "Broadband fund about the fund." Accessed: 2023-03-10. (2022), [Online]. Available: `https://crtc.gc.ca/eng/internet/fnds.htm`.

[8] Government of Newfoundland and Labrador. "Connecting rural households in newfoundland and labrador to high-speed internet." (2022), [Online]. Available: `https://www.gov.nl.ca/releases/2022/exec/0221n01/`.

[9] Xplornet Communications Inc. "About xplornet." Accessed: 2023-03-10. (2023), [Online]. Available: `https://www.xplornet.com/about/`.

[10] Northern Development. "Connecting british columbia." Accessed: 2023-03-10. (2022), [Online]. Available: `https://www.northerndevelopment.bc.ca/funding-programs/partner-programs/connecting-british-columbia/`.