Policy, Regulation, Community Wireless Networks

MINT 709 CAPSTONE PROJECT REPORT

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DECLARATION

Uppalapati Sai Krishna Teja declares that this original work was completed on Policy, Regulations, and Community Wireless Network in the Department of Computing Science, Masters in Internetworking, University of Alberta.

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LIST OF ABBREVIATIONS

CWN- Community wireless networks

CN- Community networks

AP-Access point

RF-Radiofrequency

ISP-Internet service provider

WLAN-Wireless local area network

NTIA-National telecommunication and information administration

CUWIN- Champaign-Urbana community wireless network's open-source mesh network software

AUP-Acceptable use policy

ISP-Internet service provider

SLA-Service level agreement

CRTC-Canadian Radio-television and Telecommunications Commission

NWT-Northwest Territories

CIRA- Canadian Internet Registration Authority

ICASA- Independent Communication Authority of South Africa

SATRA- South African Telecommunications Regulatory Authority

IBA- Independent Broadcasting Authority

CAK- Communications Authority of Kenya

UCC- Uganda Communications Commission

FCC- Federal Communications Commission

EBS- Educational Broadband Service

ITU- International Telecommunication Union

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ABSTRACT

Wireless community networks (WCNs), also known as wireless community projects or community networks, are decentralized, collaborative networks self-managed and self-organized locally by communities, non-governmental organizations, and cooperatives to offer consumers a viable alternative to municipal wireless networks.

Wireless networks occasionally support total freedom from censorship, which may conflict with the proper usage guidelines of some commonly used commercial services. Many businesses create wireless mesh networks that share unmetered residential and commercial cable and DSL Internet. The terms of service of regional internet service providers (ISPs) that offer their services through the duopoly of consumer phones and the line may not permit this kind of usage.

CHAPTER 1: COMMUNITY WIRELESS NETWORKS

1.1 INTRODUCTION

Access to the internet is becoming necessary to maintain a connection with today's society because the internet has evolved into a tool used worldwide for communicating, learning, and teaching. Shopping for groceries, applying for jobs, and furthering one's education are just a few examples of activities that, in the past, were carried out physically only but have since moved, either in part or in their entirety, to the digital realm of the internet. Ultimately, the Internet makes a vast amount of information available to anyone who can access it. Access to the Internet means access to employment opportunities requiring a higher level of skill and resources related to health and education. First and foremost, it is a tool that allows users to stay in touch with and be informed about the issues, events, and people most important to them as individual Internet users.

The term "digital divide" [1] refers to the gap between people with consistent access to digital technologies, such as Internet connectivity, and those who do not have such access. The gap is widening as those who need access are increasingly unable to obtain the means to get access. It is also widening even though more people are gaining access to the internet. Those who need access to the Internet, which are working-class and low-income families, are finding it increasingly more challenging to submit job applications, obtain information even though children attend school, or obtain government services.

Even for people with access, using the Internet effectively is becoming increasingly more challenging due to the rapid pace at which technology advances. Because Internet content providers design their services for users with high-speed connections, it is now possible to access a restricted amount of information if one does not have such a connection.

The Centre for Technology in the Neighbourhood [2] has websites optimized for users with a high-speed Internet connection (such as DSL, Cable, or T1) and more recent technology. Many households and individuals do not have the financial means to upgrade to a faster connection and cannot afford to buy a new computer every five years. Because of this, they are left with dated technology and an excruciatingly slow (dial-up) connection, which severely restricts their ability to use the internet. Or there is no connection between them because the costs significantly exceed the potential benefits.

It should come as no surprise that households that do not possess effective computer technology do not possess effective Internet connectivity; however, many families do have personal computers but need to keep the means for effectively accessing the internet. One solution to the problem of insufficient Internet access is the establishment of community wireless networks.

TARGETED AUDIENCE

Any group, organization, or non-profit interested in launching a community wireless network or crafting the goals and objectives of a community broadband program will find this manual useful.

1.2. The Operation of Wireless Community Networks

Instead of using landlines, wireless community networks are a type of telecommunications technology that allows access to the Internet via airwaves. Wireless community networks are arranged geographically to serve a particular area or community and enhance living standards. These networks are characterized by the interconnection of numerous individuals in a complicated web, providing adaptability to shifting bandwidth demands. Two-way radios are used in wireless, which uses an unlicensed area of the telecommunications spectrum.

Wi-Fi Spectrum: Like land, water, and air, the electromagnetic spectrum is a component of the physical world. Scope refers to the electromagnetic frequencies (wavelengths) utilized for communications, including radio, radar, Wi-Fi, and television. The Institute of Electrical and Electronics Engineers (IEEE) 802.11 standards constitute the foundation for wireless local area network (WLAN) equipment called Wi-Fi. The Wi-Fi Alliance created the word to designate these products. Most nations have laws governing the use of radio frequency bands of the electromagnetic spectrum. The Department of Industry Act, the Radiocommunication Act, and the Radiocommunication Industry govern the range in Canada [2]. This procedure is known as spectrum allocation [3].

1.3. Repeaters

Internet-connected repeaters are a type of two-way radio that may relay and send data over the network. Rooftop repeaters can be installed in the Wireless Community Network Project [2]. In other setups, repeaters are mounted on buildings or other lofty objects. Power for the repeaters must be stable and placed close to where their customers are.

Users can connect to the repeaters by Ethernet cable or a wireless card on their computer.

Mesh Network Community wireless networks require a method to adjust to minute-to-minute bandwidth demand fluctuations. Sometimes a member will wish to download a video that will use up much bandwidth for 20 minutes, but then they will only use the network again for two days. And only the fewest possible users should be affected by a repeater failure. The Wireless Community Network overcame these difficulties by using a mesh network. It connects all the repeaters in a complicated web, giving each data packet many paths to and from the Internet Gateway. The WCN has piloted and tested the Champaign-Urbana Community Wireless Network's open-source mesh network software (CUWiN) [2]. There is no fixed infrastructure for nodes in the mesh network to connect to, so individual nodes or sections of the network can become isolated from other areas. However, the network could be effectively deployed in conditions too adverse for more traditional networking systems.

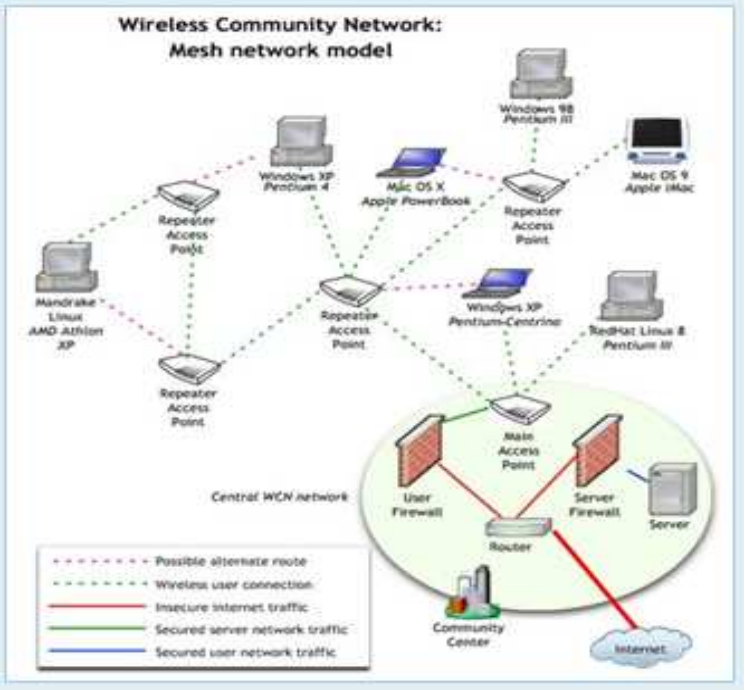


Figure 1: Network model(wireless) [2]

Wireless network deployment in economically disadvantaged areas is not a surefire fix. Partnerships with broadband providers and the promotion of easily accessible community technology centers are just two examples of approaches that can be taken to expand access to high-speed Internet in areas currently on the wrong side of the digital divide [2].

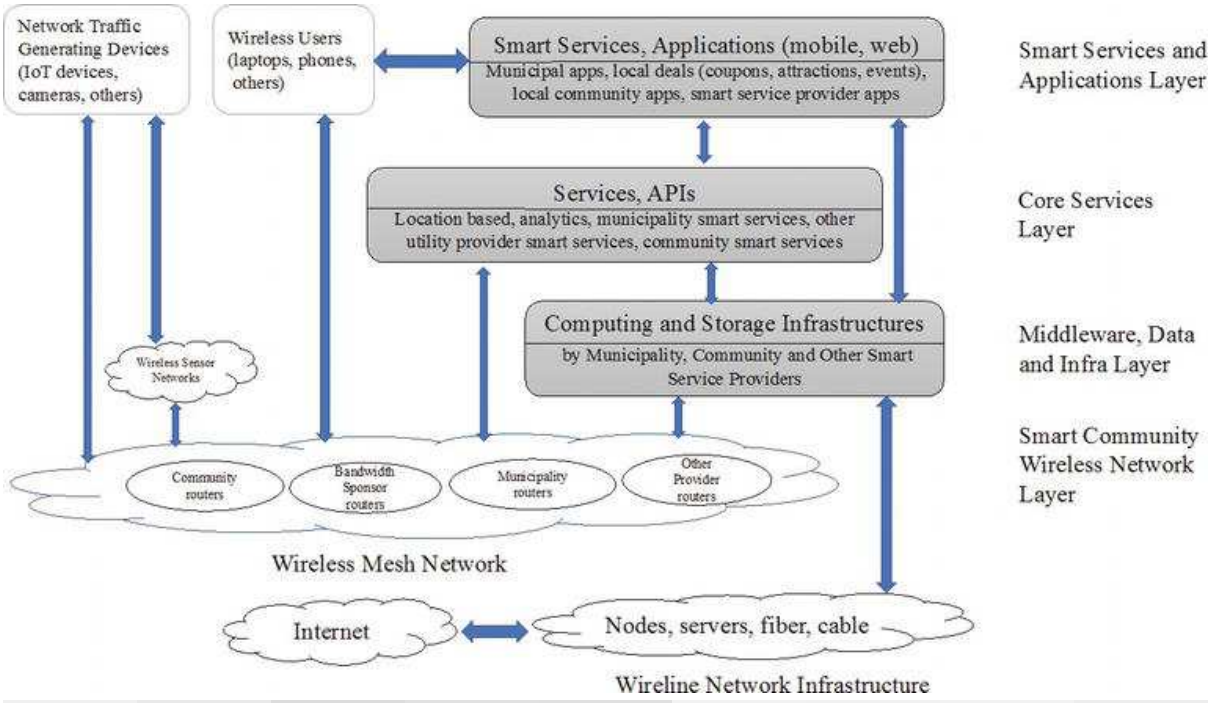
Even though the technical difficulties of constructing and mesh wireless networks have been mostly solved, this option is still being considered because of the need for a high level of

competence. The success of any effort to deploy a community wireless network depends on including paid or volunteer staff with expertise in networking, wireless communication, and system administration.

Despite this, many scenarios exist where a community wireless network is the best option. While expanding access to high-speed Internet for low-income residents was undoubtedly an aim, the networks' designers had grander ambitions. Because of its belief that the community wireless network may help achieve numerous social and economic goals. By employing the open-source software developed by the Champaign-Urbana Community Wireless Network [4], the Centre for Neighbourhood Technology [2] has created new, cutting-edge community wireless networks based on a mesh topology (CUWiN).

1.4. System architecture for innovative community wireless platform

An intelligent community wireless platform architecture could include wireless access points, cloud-based management and analytics software, edge computing devices, Internet of Things (IoT) sensors, and user devices. The wireless access points would provide connectivity to users, while the edge computing devices would process and analyze data from the IoT sensors. The cloud-based management and analytics software would enable remote system management and provide insights into its performance. The architecture would support intelligent community applications like bright lighting, traffic management, and



environmental monitoring.

The system architecture for the intelligent community wireless platform consists of multiple layers that work together to provide a range of competent services to users. The core layers include the Infrastructure Layer, the Core Services Layer, and the Smart Services and Applications Layer. The Infrastructure Layer provides the hardware and network infrastructure needed to support the platform, while the Core Services Layer offers essential services such as analytics, location tracking, and social networking. Finally, the Smart Services and Applications Layer encompasses the intelligent services of competent service providers, including transportation, health, and government-related services. It offers APIs for application developers to access these services. The system architecture provides various intelligent community services y over a wireless network.

The system architecture description for the intelligent community wireless platform is based on the typical layered approach in designing such systems. As noted, layered architectures are commonly used in developing smart platforms to deliver services to users [5].

Smart Community Wireless Network Layer: The Smart Community Wireless Network Layer is built on top of wireline infrastructure, consisting of network nodes, servers, and cabling. Wireless access points and other technologies are used to provide wireless connectivity. This layered architecture allows flexibility and scalability for innovative community applications such as traffic management and environmental monitoring.

Middleware, Data, and Infra Layer: The Middleware, Data, and Infra Layer stores data and provides computing and storage resources through the community, municipality, and intelligent service providers' infrastructures. This layer includes middleware, service-oriented solutions, cloud computing infrastructures, and reliability, security, privacy, and trust solutions. Innovative service providers host the data and resources for intelligent services, which can be accessed through the wireless network. This layer must be capable of storing and processing various data types, including real-time processing and handling complex intelligent services.

Core Services Layer: The Core Services Layer provides essential services such as analytics, location tracking, search, and social networking to users through a wireless network. This layer also includes data mining and geospatial services and is typically available to bandwidth sponsors and intelligent service providers.

Smart Services and Applications Layer: The Smart Services and Applications Layer encompasses the range of intelligent services provided by competent service providers, including those related to transportation, health, and government. The layer offers APIs for application developers to access these services and user applications developed by municipalities, communities, and intelligent service providers for both web and mobile platforms.

1.5. Networking Methods for Internet access

- Hotspots, also known as access points, are locations where wireless broadband Internet signals are disseminated to the nearby geographic region. Typically, coverage reaches around 300 meters from the originating signal, though the range can be increased with an external antenna. Île Sans Fil(Montreal, Quebec, Canada) [6] and Wireless Toronto(Toronto, Ontario) [7], two community Wi-Fi organizations, use hotspots to display local artwork, support the growth of local community content production, and give local companies and organizations a convenient way to share bandwidth.
- Hub-and-spoke systems: In remote locations, a solitary powerful antenna can transmit a signal from, say, a hill to the residences in the valley below. In fixed wireless deployments, hub-and-spoke systems are frequently used to disperse a call in places where the Fiber-optic cable cannot be deployed owing to geographic or financial constraints. These Systems work best when the neighborhood can afford to buy and share enough bandwidth. The city of Fredericton's Fred Ezone [8] comprises hubs and spokes joined by adequate backhaul bandwidth.
- Dynamic mesh: In this setup, connected nodes in a neighborhood share bandwidth obtained through a high-capacity backbone. Building strong local area networks is possible because each node can communicate with the Internet and other nodes. The connection between nodes is just as crucial to the smooth operation of mesh networks as communication with the Internet. Many people or organizations must be ready to contribute their Internet backbone to deploy mesh networks. The Champaign-Urbana Community Wireless Network (CUWin) has developed the most reliable and adaptable software for creating community mesh networks (http://www.cuwireless.net/). BC Wireless [4] in New York has experimented with mesh networks despite not having a reliable provider for their Internet backbone. As a result, their systems primarily connect nodes rather than many people to the Internet.

In Canada, hub-and-spoke networks and occasionally (though infrequently) mesh networks are used in municipal projects, whereas most community wireless initiatives focus on establishing WIFI hotspots. Although wireless mesh networks have been effectively accepted in US towns and developing countries, it is still being determined exactly how they will be deployed.

CHAPTER 2: BUILDING COMMUNITY WIRELESS NETWORKS

Three fundamental approaches to building community wireless networks are:

- Cluster: Organizations that only promote the sharing of unmetered internet traffic through Wi-Fi may additionally index nodes, recommend a single SSID (for subpar roaming), provide equipment, DNS services, etc.
- Technology organizations that coordinate constructing a mesh network for Wi-Fi internet access are known as wireless mesh networks.
- Device-as-infrastructure: By creating a peer-to-peer network that is still functional when not connected to a vast area network, the Commotion Wireless mesh network firmware released by the Open Technology Institute in 2013 enables Wi-Fi-enabled mobile phones and laptops to join a wireless community network [9].

This chapter will give you an insight into how to build a community wireless network.

2. COMMUNITY WIRELESS MESH NETWORKS

These networks connect people within the community and allow community members to share their internet access. There is a difference between business models and community network models in terms of their implementation, ownership, and how they are managed.

Implementation:

The implementation phase is done by community-based organizations, and every individual works toward how to plan, design and deploy these networks.

Ownership and management duties:

These duties are performed by the individuals who belong to the community and volunteer their time and expertise.

This part of the chapter will give you an idea of how to build community wireless networks through some approaches, and they are as follows:

2.1. Determine Who Your Community's Partners Are and What Partnership Means

This is a crucial step in identifying how the network has to be planned, developed, and maintained and their role in fulfilling their responsibilities, as they are accountable for the initiative taken.

- Identify the area for the pilot network to be established: During this phase, we need to ensure that the critical locations in the community are initially connected when the network plan is made. This may include residents of the organizations and supporters of the initiative. We need to ensure these areas have good signal strength and get access from the property owners to install a node.
- Reaching out to the community and organizing: Getting feedback from the community members through surveys and general meetings to ensure that everyone is equally involved in the project and that it's not a service offered by an individual. It is also equally important to make people aware that there are costs associated with establishing the network and often encourage them that ideas are welcomed if an individual finds a way to minimize these costs
- Training the members within the community: This phase answers the questions like who will educate the members within the community to operate the computers and provide additional support or assistance if needed. Members must be trained on how technical support is assured and from where.

2.2 Determining the role of these partnerships and relationships with other organizations is essential

As the plan is to construct a CWN, we must think out of the box to establish relationships with other organizations such as schools, post offices, museums, etc. There is scope for creating awareness among people about how these networks can improve every individual's quality of life.

2.3 Create and investigate your network

The deployment of the network and the successful communication between different devices across the community should be the primary focus of CN developers.

As a result, the architects of CN should educate users in the community on how to join the network and continue to grow the network's coverage area.

2.4 An outlook on mesh networking

Wireless mesh networks are networks constructed using radio nodes within a mesh topology. It can also be in the form of a wireless ad hoc network. Mesh networks can be utilized for any application in which the network end nodes are situated at a distance that prevents them from sharing to a central location with direct access, such as an internet

connection. Across the entirety of the network, any variety of network protocols may be utilized.

How do they function:

Mesh nodes, mesh clients, and mesh gateways are the three essential components of wireless mesh networks [10].

WAP devices that have various radio systems are known as **mesh nodes**. The nodes serve both as endpoints and as mesh routers. The firmware allows them to share data with other nodes that belong to the network.

Clients of a mesh network are mobile computing devices that communicate wirelessly, such as laptops, mobile phones, and tablet PCs.

Nodes known as gateways connect two separate networks that operate under distinct protocols. Whenever data enters or leaves a network, it must first travel via the gateway.

Because every node in a WMN has at least one, and sometimes more than one, the path leading to other nodes, many information pathways can be established between any given pair of users. Because of this, the network is made more robust, and even if a WAP or connection fails, data can still access other nodes in the network [10].

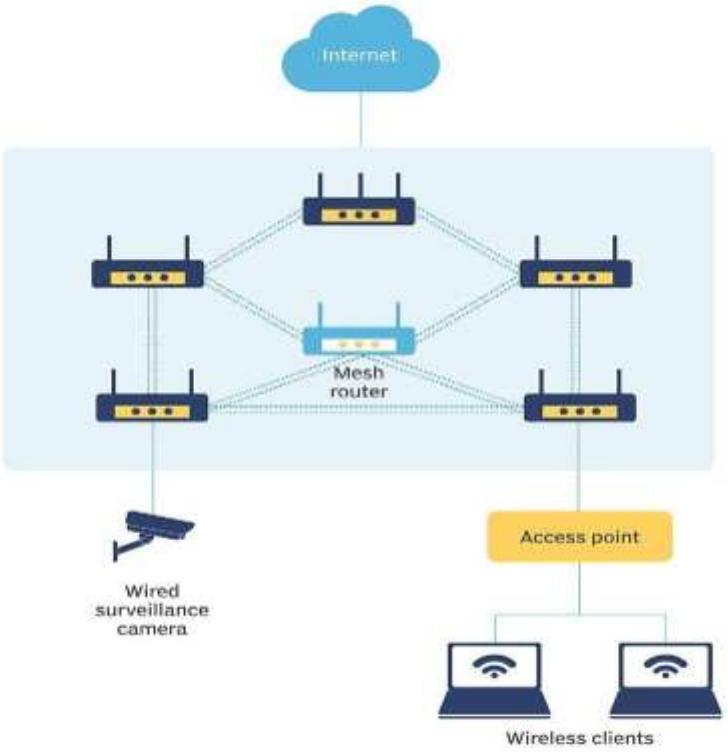


Figure 3: Representation of the mesh network [10]

Advantages of a mesh network:

- The primary benefit is that it can have a single node to establish an internet connection physically
- These networks are reliable as they do not complicate the network and ensure a smooth flow. There is continuous data communication even if one node loses connection since the other picks up.
- These networks are cost-efficient as it reduces the cost of installing fiber and wires.
- Configuration can be done dynamically.
- Less power consumption is another benefit of using these networks
- They are scalable as nodes can be added to the network easily

Understanding the mesh network is essential in designing the network to connect the people in the neighborhood.

Mesh structured networks

These networks can be hierarchal. It has a hub for connecting people through which it can connect to a central device that controls the load on the web.

HUB AND SPOKE: The hub-and-spoke topology, also called the star topology, is one of the most common, time-tested, and standard configurations for all kinds of networks. The access point is physically connected to the Internet using a wire. All user devices link to the wireless router in the center of the network, similar to how spokes on a wheel connect to the center of the wheel. All network traffic must pass through the hub to communicate with other spokes or establish a connection with another network.

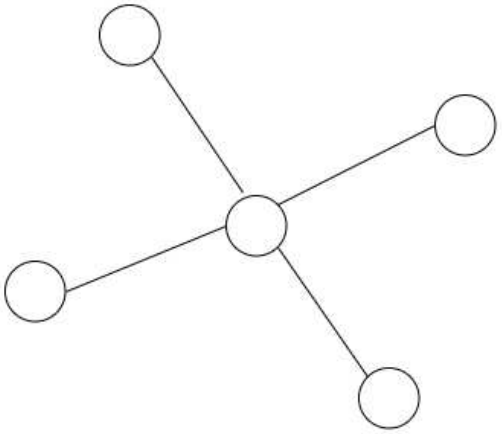


Figure 4: Representation of hierarchal network or mesh structure

MESH NETWORKS DIFFERENTIATE FROM THE NON-MESH NETWORKS IN TERMS OF ROUTING

The main difference is that mesh networks can connect over other devices without a central hub.

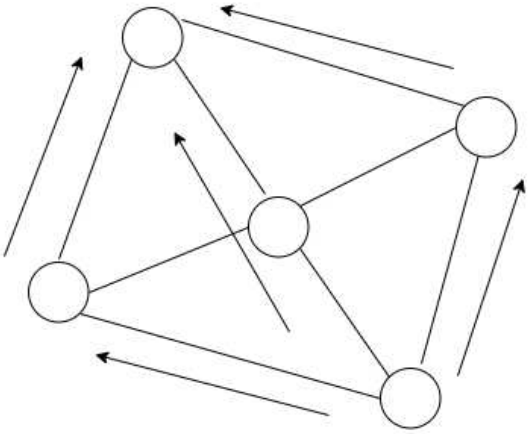


Figure 5: Shows the pictorial representation of mesh networks in terms of their routing.

The router is a device that controls data flow throughout a network. It used a hub and spoke architecture. The WIFI access points we use at home or on smartphones cannot easily communicate with other routers.

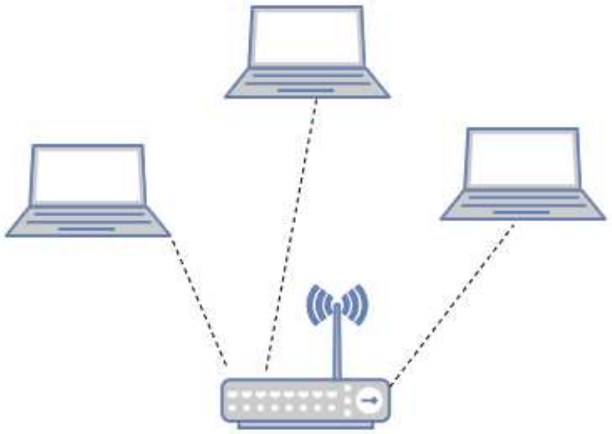


Figure 6: Basic mesh structure with the wireless hub connected across different devices

Routers can dynamically communicate with each other in a mesh-enabled structure so the load or traffic of the router can be minimized. A network's central node can be a mesh device, or there can be no central node.

2.5 Wifi -Signals With Their Frequency Bands:

Understanding Wi-Fi signals and their frequency bands is essential for building wireless networks. Every individual in the community has to know these characteristics.

2.4 GHZ is the Wi-Fi band with the lowest primary frequency. This was the first widely used Wi-Fi technology that could be used for wireless networking in a local area. It is used by many legacy devices, which means that the signals are frequently more congested (particularly in urban locations). This might result in interference and decreased throughput speeds. However, in contrast to the 5 GHz frequency, this spectrum is better at penetrating obstacles like walls and windows of every individual's residence within the community.

The 5 GHz Wi-Fi band is a higher frequency that was added to Wi-Fi during the past few years and has the potential to attain more incredible speeds on occasion because the frequencies are less busy. Therefore, while having a lesser range and being unable to pass

through obstacles like walls and windows as signals on the 2.4 GHz band can, its throughput is frequently better**.**

Figure 7: Shows the difference between 2.4ghz and 5ghz [11]

Compared to 2.4 GHz, 5 GHz will give you a stronger signal and better speed over a shorter distance.

Table 1: Differentiating the abilities of 2.4 and 5 GHz frequency bands

2.4 GHZ	**5 GHZ**
Greater surface area is covered.	**The data rate is high.**
Ability to pass through solid things	**Less interference prone**
Used for a device that is far from the router	**Use when the device is closer to the router**

2.6 Antennas Used in Building Wireless Networks

This chapter section will cover the antennas we use to construct wireless networks.

Usually, the antennas are used by the routers, and what kind of antenna should be used depends upon the choice of the individuals within the community. But there are three most commonly used antennae, and they are as follows:

- Omni directional antennas
  - Directional antennas

    Sector antennas

    Focused antennas

First, we will look at the Omni directional antennas

2.6.1 Omni directional antennas

This kind of antenna sends the signal in all directions equally. One primary benefit of using these is that they can connect in any order. But the problem is that it limits its signal strength. That is, it weakens the signal in any one direction. It emits a spherical-shaped signal.

Because their signal can be received from any direction, omnidirectional antennas help receive a signal from a source the user needs clarification on. This type of signal can be picked up from any angle. Broadcasting a hotspot from a central position at a site like a park, fairground, or backyard in the community is yet another excellent use for these devices.

The advantages of using these kinds of antennas are:

- We can connect to a hotspot when moving on a vehicle within the community
- We can connect to a hotspot whose location is not known

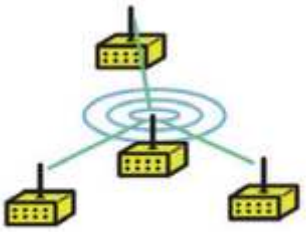


Figure 8: Representation of omnidirectional antennas [12]

2.6.2 Directional antennas

A radio-frequency (RF) wireless antenna, called a directional antenna, had been engineered to perform more successfully in specific directions than in others. In this kind of antenna, the

signals are sent out in a more focused way. This directionality is being implemented to enhance both the transmission and reception of communications while lowering interference.

Two kinds of directional antennas are:

Sector antenna: This kind of antenna sends out pie-shaped signals. They are generally bounded by the router or separated and are long and rectangular. They are usually between 30 to 120 degrees.

Figure 9: Visual representation of sector antenna [12].

Focused antenna: They send out a narrow signal beam, also known as point-to-point antennas. They are usually 5 to 10 degrees long.

The disadvantage of directional antennas is that building links in your neighborhood takes more preparation. We must consider how wireless signals will cover our community to ensure no one is left out. As CN developers, we define and restrict their travel areas as a community.

Figure 10: Visual representation of the focused antenna [12].

2.7 Role of Devices for Wireless Networks

WIFI devices use three kinds of modes, and they are:

- Client operation, i.e., station
- Access mode
- Mesh mode

2.7.1 Wireless client mode(station)

We use these devices, such as computers, tablets, and phones, to connect to a network. When we access a wireless hotspot through a machine, it can be called a client.

Wireless clients are considered separate devices from access points (APs), even though some routers can also function as clients. This enables the router to connect to another Wi-Fi access point (AP) like our computer or smartphone would, which can be beneficial when bridging two distinct networks.

2.7.2 Access points

This can be called a master. Access points are usually used to create wireless networks. Wi-Fi we use at the residence is through an access point, the router. It acts as a bridge between wireless and wired networks.

Figure 11: Wireless access point [13]

2.7.3.AD-HOC MODE

Sometimes wireless devices connect without using an access point between them. These form a different network, as every node is responsible for sending and receiving data from one device to another within the range. They can be used to create mesh networks, so when they operate in that mode, it is known as mesh mode.

Few things to remember

- Wireless connections between Access Points are not possible.
- Wireless connections between clients are not possible.
- Wireless Ad-Hoc (Mesh) device connections are not possible for clients.

- Wireless Ad-Hoc (Mesh) device connections are impossible with Access Points.

2.8 Mesh Network Scenario for the Neighbours Within the Community

Every node in a mesh network connects to every other node within range, expanding the concept of a point-to-multipoint network. As a result, a "Multipoint-to-Multipoint" network is created. Since wireless devices operating in AP or Client mode cannot make peer-to-peer connections, this network architecture typically requires all devices to be in Ad-Hoc mode.

On the roofs of numerous buildings, wireless mesh nodes have been erected. Nodes within range of one another will automatically link to one another. All of the resources that are related to these nodes will be shared. To allow users to access these resources from any location on the network, these Ad-Hoc nodes can also be connected to PCs, access points, or routers inside the buildings.

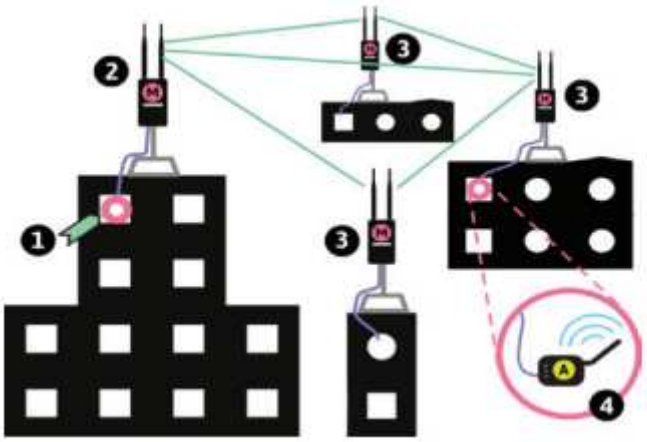


Figure 12: Model representation of mesh wireless network connecting neighborhood in the community [12]

The above figure represents the mesh nodes with M connected to the antenna for internet connectivity. All the other mesh nodes receive an internet connection from the mesh node(2). An access point is represented by (A), responsible for distributing the internet within the community.

2.9 Conclusion with Some Useful Insights for Building the Community Wireless Networks

- Before building the networks, having as much information as possible on each installation and its sites is crucial, so identifying areas is significant for each Installation.

- Ask the people in the community what they need through feedback on what sites should be given more priority.
- As the community wireless networks depend on the line of sight, the router placement has to be identified carefully, as the signal can diminish if devices cannot see each other.
- We must ensure the nodes can see each other when connecting across the neighborhood. Router placement is crucial. If two routers are placed between a tress or any other building, they may need help communicating with each other so the signal can be degraded.
- Best method is to build them in layers, with a topmost layer having the Prime connectivity and the middle layer distributing the traffic moving towards the top layer. The lowest layer helps in getting people to connect and go online.
- Using multiple layers helps in better performance reliability and capacity.

CHAPTER 3: ACCEPTABLE USE POLICIES AND CHALLENGES OF SPECTRUM SHARING IN CANADA

3.1 Introduction to Acceptable Use Policies

Generally, acceptable use policies are rules that one must agree to access a network or internet connection. It gives a brief idea to people on what they can or cannot do when connected to an organizational network.

An acceptable usage policy (AUP) is helpful for companies and educational institutions that give their employees or students access to the internet. They must provide their consent to these terms and conditions before they can be allowed access to the network. Similarly, when you join up with an internet service provider, they will typically have you sign an acceptable use policy (AUP) that stipulates that you must adhere to a particular set of requirements.

The goal of an acceptable use policy (AUP) is to ensure that internet access is exclusively utilized for appropriate activities by all users. If users are restricted in their actions, internet service providers will be better able to comply with the law and safeguard their customers from cybersecurity risks [14].

The following is a list of conditions that might be included in an AUP:

- While using the service, you should avoid breaking the law.
- Do not make any attempt to penetrate the network's security or the security of any of the users on the web.
- Do not make any attempt to transmit unsolicited junk mail or spam.
- Do not attempt to crash a website’s server by sending spam or many emails.

- You must report any suspicious activity you observe on the network.

3.2 Importance of Acceptable Use Policy

As many of the carriers provide internet access then, we require AUP for the following reasons:

Cybersecurity Threats Should Be Avoided

Businesses and institutions want to be able to regulate what happens on their networks somehow. An element of maintaining a secure network is limiting what users may view, download, and search on the internet. Your network could become accessible to hackers and viruses if a student or employee were to open an unsafe attachment or go to dangerous websites [15].

Make sure that users stay away from illegal activity.

An AUP can assist in ensuring users are abiding by the law. For instance, a user's ability to pirate music, movies, or other materials may be forbidden under an AUP. It might state that anyone who breaks these guidelines will be kicked off the network. Outlining these illegal actions in your AUP is crucial because it protects your company from liability if users breach the law while using your network.

3.3 Making Sure Employees follows Acceptable Use Policies

Getting people to accept your terms and conditions is one thing; confirming that they are being followed is quite another. Use the following advice to encourage people to respect and follow your AUP:

- Declare Your Policies
- Make a Plan to Address Issues
    - People are more likely to adhere to your rules when they know there are repercussions for breaking your AUP. Clearly define the management's policy regarding what will happen if someone is discovered abusing the network. You must apply these penalties consistently if a user violates your AUP. People are less inclined to take your AUP seriously if you constantly give them a pass.
- Make Use of Plain Language and an Uncomplicated Format while writing your AUP

- Put the knowledge of the people to the test.

  After someone has read the policy, you should test their comprehension of the document. The fact that individuals will be required to demonstrate their knowledge of the AUP through a brief test will encourage them to read the entire policy. If you want anyone to feel comfortable with the information contained in the AUP, you should be willing to clarify any aspect of the document to them [14].

3.4 Key Aspects of AUP

Usually, customers must sign an AUP when ISPs give them internet access. That is the service level agreement. It is part of an agreement between the ISP and the customer.

- not using the service in a way that breaks any laws.
- not attempting to compromise the information security of any computer network or end user, such as when using the internet.
- not posting advertisements or solicitations to Usenet groups without first obtaining authorization.
- not sending unsolicited electronic mail or spam to anyone who has indicated they do not wish to receive it.
- not trying to flood a server by sending many emails to one particular website.
- not trying to flood a server by sending many emails to one specific website.
- users are required to report any attempt made to breach their accounts.
- recognizing that the AUP complies with applicable law as applied to IT and associated concerns and may be subject to periodic audits [15].

3.5 Wireless Carriers in Canada

Canada's big three wireless carriers are Rogers, Telus, and Bell. They are called the big three telecom service providers in Canada.

In Canada, only the "Big Three" mobile phone service companies are the ones to sell mobile plans that include "unlimited" data. These plans provide customers with a limit of high-speed data usage per month. When a consumer reaches their monthly limit of high-speed data usage, often between 20 and 100 gigabytes (GB), the customer can continue to use data, but the speed is reduced to a much more gradual pace.

3.6 Summarization of Differences in Acceptable Use Policies of Rogers, TELUS, and Bell

The major players in the Canadian telecommunications industry include Bell, Rogers, and Telus. Each of them has devised its policies regarding the utilization of public wireless networks.

However, prior authorization is required to install any equipment on Bell's network infrastructure. Although Bell permits using its network for community wireless networks, this does not apply to its network. In addition, they mandate that the equipment must fulfill several predetermined technical requirements and that the community network operator be the one in chars installation, maintenance, and day-to-day operations [16].

Rogers requires community wireless network operators to enter into a formal agreement with the company to ensure their network's correct use. This requirement is similar to Bell's, which requires community wireless network operators to enter such an agreement. Rogers mandates that the district wireless network operator provide sufficient liability insurance and that they comply with all laws and regulations at the time [17].

Telus also permits using its network for community wireless networks; however, the company has a more inclusive policy that addresses various concerns, including network security, privacy, and quality of service. Telus places significant importance on the network's safety and the users' privacy, and they mandate that the operators of community wireless networks implement appropriate security measures to safeguard the network and its users. They also require that community wireless networks enter into a formal agreement with the company and that these operators comply with all laws and regulations that are currently in effect [18].

To summarize, Bell, Rogers, and Telus all permit the use of their network for community wireless networks; however, each company has its own set of specific requirements and policies to adhere to guarantee their network's correct utilization. These policies differ from one another in terms of the scope that they cover. Still, they all have the same overarching objective of ensuring their network's privacy, security, and dependability [16] [18] [17].

3.7 Introduction to CRTC

The Canadian Radio-television and Telecommunications Commission, also known as the CRTC, is an independent public organization responsible for regulating and supervising

Canada's broadcasting and telecommunications systems. This organization's mission is to ensure that consumers in Canada have access to a communication system of world-class caliber and to promote a competitive and dynamic marketplace for providing communication services [19].

The CRTC is responsible for a variety of things, including the following:

- Controlling and monitoring the radio and television broadcasting as well as the telecommunications systems in Canada
- granting licenses and imposing regulations on services and facilities related to broadcasting and telecommunications
- Ensuring that all Canadians have access to fundamental forms of communication, such as high-speed internet and telephones, is a priority for the Canadian government.
- Fostering the production of Canadian content across the country's various broadcasting platforms
- Making sure that the legal rights of customers are safeguarded within the context of the communication systems

- The CRTC ensures that consumers, businesses, and the general public are considered when making decisions. These decisions have a significant bearing on the progression of Canada's communication infrastructure [19].

Regarding community wireless networks in Canada, the CRTC has several goals in mind, including the following:

- Accessibility: The CRTC's mission is to ensure that all Canadians, regardless of location, access essential telecommunications services, such as high-speed internet. This includes encouraging the installation of community wireless networks in rural and remote areas, where there may be fewer options for internet connectivity overall.
- Affordability: The CRTC ensures that communication services are affordable for Canadians. It encourages the development of community wireless networks that can provide affordable and accessible internet services to local communities. The CRTC also ensures that communication services are affordable for international visitors to Canada.
- Competition: The CRTC is committed to fostering competition in the communication systems, including community wireless networks, to guarantee that residents of

Canada have access to a diverse range of communication services and providers offering services at reasonable costs.

- The Canadian Radio-television and Telecommunications Commission (CRTC) supports the development of new and improved services for Canadians by encouraging innovation in communication systems, including community wireless networks.
- Consumer protection: The CRTC is responsible for ensuring that the rights of consumers are protected within the communication systems, including community wireless networks, and it works to resolve disputes between consumers and communication service providers [19].

The CRTC's goal in regulating community wireless networks in Canada is to balance the interests of consumers, the industry, and the general public. Additionally, the CRTC works to promote a communication system that is both healthy and dynamic for all Canadians.

3.8 The Consequences and Difficulties that come with Sharing the Spectrum

Spectrum sharing is a method that allows multiple wireless networks to share the same frequency spectrum. This is accomplished by using a technique known as spectrum sharing. This has the potential to have significant implications for the efficiency and effectiveness of wireless communication; however, it also poses several challenges.

IMPLICATIONS

- Spectrum sharing enables multiple networks to share the same frequency spectrum, enabling more efficient use of the available limited range. Spectrum sharing allows for more efficient use of the available narrow scope. As a result, there is less of a requirement for allocating additional spectrum, which can result in significant cost savings for network operators.
- Sharing frequency spectrum can also reduce the cost of acquiring and operating frequency spectrum, which can be a significant expense for network operators. This can result in cost savings for the network operators. By sharing range, operators may

reduce their capital expenditures while improving their network coverage and capacity through spectrum sharing.

- Spectrum sharing can improve end users' service by improving connectivity and the speed at which data can be transmitted. This improvement can be attributed to spectrum sharing enabling better connectivity. Users can use faster speeds and more reliable connections if the spectrum is shared, which can help alleviate network congestion and boost capacity.
- Increased innovation: Companies can innovate and develop new technologies and applications requiring higher bandwidth if more spectrum is available. Sharing spectrum can create a more innovative environment, leading to the development of products and services that end users will benefit from.
- In general, spectrum sharing will significantly affect the wireless industry. These repercussions include more effective use of the limited frequency spectrum, reduced costs, improved service for end users, and increased innovation.

CHALLENGES

- Interference: Spectrum sharing can result in interference between networks, which can either decrease performance or complete service disruption. Interference can hurt both. Network networks ensure they do not transmit simultaneously or within the same frequency range to prevent interference. This complicated and challenging process calls for network operators to communicate with one another and coordinate their efforts.
- Coordination: To ensure that all networks using the spectrum do so equitably and effectively, spectrum sharing necessitates coordination between the various networks. This coordination process can be difficult and complex, mainly when dealing with multiple networks with different technical requirements and operational goals.
- Spectrum sharing can raise concerns about security and privacy because it increases the likelihood that sensitive data will be intercepted by users who are not authorized to access it. The operators of a network are required to take precautions to secure their networks and prevent unauthorized access to user data.

- Standardization: To facilitate interoperability between various networks, spectrum sharing necessitates standardizing the technologies and protocols. This can present a challenge due to the wide variety of wireless technologies and standards that are currently in use, as well as the possibility that specific networks are more compatible with particular standards than others.
- Fairness: To guarantee that all networks have equivalent access to the spectrum, spectrum sharing needs to be conducted fairly and equitably. This can be difficult to achieve in practice, particularly when some networks have greater power or influence. To foster competition and encourage innovation in the wireless industry, it is essential to guarantee fairness and equal access to the spectrum.
- Challenges for Regulatory Bodies: Spectrum sharing can present difficulties for regulatory bodies, which are responsible for ensuring that the spectrum is used by applicable regulations and standards while simultaneously encouraging innovation and expansion in the wireless industry. Regulators are responsible for balancing the competing interests of various stakeholders, such as network operators, end users, and the general public.

Interference, coordination, maintaining security and privacy, ensuring fairness, adhering to standards, and meeting regulatory requirements are some difficulties associated with sharing the spectrum in wireless communication. Conquering these obstacles is essential to encourage the effective and equitable use of the limited frequency spectrum, enabling the wireless industry to continue its growth and innovation.

3.9 Spectrum Sovereignty

Spectrum sovereignty refers to a country's right to manage and control the use of radio frequency spectrum within its borders. This concept is based on the idea that the range is a limited and valuable resource. As such, countries should be able to regulate their use to ensure efficient and effective spectrum use. However, the challenge arises when waves propagate through the borders of other countries. Radio waves do not respect national boundaries and can travel across borders, potentially interfering with different nations' use of the same frequency bands [20].

To address this challenge, international treaties and agreements have been established to ensure cooperation and coordination between countries regarding the use of the radio spectrum. The International Telecommunication Union (ITU), a specialized agency of the

United Nations, plays a crucial role in coordinating the global use of the range and resolving disputes that may arise between countries. The ITU works with member countries to allocate frequency bands and establish technical standards [20]. Governments must enforce these standards within their borders and coordinate with neighboring countries to prevent harmful interference.

In some cases, spectrum disputes between countries can arise. These disputes may be related to the allocation of frequency bands or the use of certain technologies that may interfere with neighboring countries' spectrum use. To resolve these disputes, the ITU facilitates negotiations and works to find mutually acceptable solutions for all parties involved. In this context, the following are seven ideas on how this challenge can be addressed:

- **Establishing bilateral agreements:** establishing bilateral contracts can be an effective way for countries to manage the use of the radio frequency spectrum across borders. These agreements can help promote cooperation, minimize interference, and ensure efficient spectrum use.

  Bilateral agreements can include provisions for sharing information related to spectrum use, such as information on frequency allocations and technical parameters. This can help countries to understand each other's spectrum use better and to identify potential areas of interference. Bilateral agreements can also provide for cooperation on interference issues, such as coordinating radio frequency spectrum assignments and resolving interference disputes. This can help minimize harmful interference and ensure the spectrum is used efficiently and effectively [20].

  In addition, bilateral agreements can facilitate the coordination of spectrum use, particularly for spectrum-dependent applications such as satellite communication and broadcasting. This can help to ensure that these applications can operate effectively and do not interfere with other spectrum-dependent applications. Overall, bilateral agreements can be an effective tool for managing the use of the radio frequency spectrum across borders. By promoting cooperation, minimizing interference, and ensuring efficient spectrum use, these agreements can help support the development of wireless communication technologies and the delivery of a wide range of applications and services that depend on the scope.
- **Harmonization of spectrum use:** Harmonising radio frequency spectrum across borders is crucial to minimize interference and ensure efficient spectrum use. This is

because radio waves do not respect national boundaries, and as such, the use of spectrum by one country can affect neighboring countries.

Regional and international coordination and standardization efforts are essential to achieve this goal. The International Telecommunication Union (ITU) plays a crucial role in coordinating the global use of the spectrum and establishing technical standards for its use. The ITU works with member countries to allocate frequency bands and develop technical standards for their use [21].

In addition to the ITU, regional organizations such as the European Telecommunications Standards Institute (ETSI) and the Asia-Pacific Telecommunity (APT) also play a crucial role in coordinating spectrum use across borders in their respective regions. Standardization efforts can also help minimize interference and ensure efficient spectrum use. For example, using common technical standards for wireless communication technologies, such as 4G and 5G, can provide interoperability between devices and networks, minimize interference, and promote efficient spectrum use [21].

- **Development of advanced technologies:** the development of advanced technologies such as cognitive radio and software-defined radio can significantly impact the efficient use of the radio frequency spectrum. These technologies enable dynamic and adaptive radio frequency use, which can help to minimize interference and improve the overall efficiency of the range.

  Cognitive radio is a technology that enables devices to intelligently sense their environment and adjust their radio frequency use accordingly. This technology can help identify unused or underutilized frequency bands and enable machines to access these bands to minimize interference with other spectrum users. Cognitive radio can also allow devices to dynamically adjust their frequency based on changing conditions, such as the presence of other spectrum users or changes in the propagation environment.

  Software-defined radio (SDR) is another technology that enables dynamic and adaptive radio frequency use. SDR devices can be programmed to operate on a wide range of frequencies and adapt their radio frequency use based on changing conditions. SDR devices can also be reconfigured remotely, which can help to enable more efficient spectrum use and minimize interference [21].

  Overall, the development of advanced technologies such as cognitive radio and software-defined radio can help to improve the efficient use of the radio frequency

spectrum. By enabling dynamic and adaptive radio frequency use, these technologies can minimize interference, support more efficient spectrum use, and help to support the development of a wide range of wireless communication technologies and applications.

- **Strengthening international regulatory frameworks:** International regulatory frameworks such as the International Telecommunication Union (ITU) can significantly harmonize spectrum use across borders. Strengthening such frameworks can improve coordination and reduce interference.
- **Encouraging sharing and collaboration:** Encouraging sharing and cooperation between countries can lead to efficient spectrum use, reduced costs, and increased innovation. This can be achieved through joint research and development initiatives and knowledge-sharing platforms.
- **Developing national strategies:** Countries can develop strategies to address spectrum sovereignty challenges. Such techniques can include policy frameworks, capacity building, and stakeholder engagement.
- **Investing in monitoring and enforcement:** Monitoring and enforcement mechanisms can help identify and address interference, piracy, and unauthorized spectrum use cases. This can include deploying monitoring equipment, developing legal frameworks, and strengthening law enforcement agencies [21].
- In conclusion, managing the radio frequency spectrum across borders is a complex challenge that requires international coordination and collaboration. Addressing this challenge requires technological, regulatory, and policy solutions. The above ideas are some ways countries can address the spectrum sovereignty challenge.

3.10 Costs and Procedures for Purchase of Backhaul

Backhaul refers to data transmission from an end user's device to a central location, such as a data center or a network provider's point of presence (PoP). Backhaul networks are typically used to connect smaller local networks to more extensive, long-distance networks. The costs and procedures for purchasing backhaul can vary depending on several factors, including the distance between the end user and the central location, the type of backhaul technology used, and the required service level.

Types of backhaul technology

- **Fiber optic backhaul**: This backhaul provides high-speed connectivity over long distances, making it ideal for transmitting large amounts of data. The cost of fiber optic backhaul can vary depending on factors such as distance and the number of fibers required.
- **Microwave backhaul**: Microwave backhaul uses radio waves to transmit data over short distances. It can be a cost-effective alternative to fiber optic backhaul in certain situations, such as rural areas where fiber infrastructure is unavailable.
- **Satellite backhaul**: Satellite backhaul can provide connectivity in remote areas where other backhaul types are unavailable. However, it can be more expensive than different types of backhaul due to the cost of satellite equipment and bandwidth.

Cost factors when purchasing a backhaul

Several factors can influence the cost of purchasing a backhaul. These factors can vary depending on the backhaul technology, the distance between the end user and the central location, and the required service level [22]. Here are some of the most common cost factors to consider when purchasing a backhaul**:**

- **Distance:** The distance between the end user and the central location is one of the most critical factors in determining the cost of backhaul. Longer distances generally require more expensive technology and infrastructure. For example, fiber optic backhaul may be more costly for longer distances due to the cost of laying and maintaining the fiber optic cables. Similarly, satellite backhaul may be more expensive for longer distances due to satellite equipment and bandwidth costs [22].

- **Bandwidth:** The amount of data that needs to be transmitted can also impact the cost of backhaul. Higher bandwidth requirements generally require more expensive equipment and infrastructure [22]. For example, if you require high-speed, low-latency connectivity, you may need to invest in more advanced equipment and infrastructure to support that level of bandwidth. This can include fiber optic cables with multiple fibers or specialized microwave equipment.
- **Service level:** The service level required can also impact the cost of the backhaul. Different service levels can be provided depending on the needs of the customer. For example, a higher service level may include guaranteed bandwidth and uptime but

may come at a higher cost. Alternatively, a lower service level may be more cost-effective but may not provide the same level of performance or reliability.

- **Type of backhaul technology:** Backhaul technology can also impact the cost. Fiber optic backhaul, for example, can be more expensive than a microwave or satellite backhaul due to the cost of laying and maintaining the fiber optic cables. Similarly, microwave or satellite backhaul may be more costly if specialized equipment or higher bandwidth is required [23].
- **Infrastructure:** The existing infrastructure in the area can also impact the cost of backhaul. If there is already fiber optic infrastructure, purchasing fiber optic backhaul may be less expensive. Similarly, if microwave or satellite equipment is already in place, using those technologies for backhaul may be less costly.
- **Competition:** Finally, the market competition level can impact the cost of backhaul. If multiple providers offer backhaul services in a particular area, it may be possible to negotiate lower prices or more favorable service level agreements [23]. On the other hand, if there is a limited number of providers, the cost of backhaul may be higher due to the lack of competition.

Procedures For Purchasing A Backhaul

The process of purchasing a backhaul can vary depending on the specific requirements of the customer and the type of backhaul technology being used. Here is a more detailed breakdown of the typical procedures involved in purchasing a backhaul:

- **Identify your needs:** The first step in purchasing a backhaul is determining your specific requirements. This includes the bandwidth you need, the distance between your location and the central location, and any other requirements you may have, such as service level agreements or redundancy options. Once you have a clear idea of what you need, you can look for a provider to meet those needs.
- **Research backhaul providers:** Many providers offer backhaul services, so it's essential to research your options and find a provider that can meet your requirements. Consider factors such as the type of backhaul technology they offer, their coverage area, pricing, and service level agreements. You can also look for reviews or recommendations from other businesses or industry contacts [23].

- **Please request a quote:** Once you have identified a few potential providers, contact them and request a quote for the backhaul service you need. The provider will likely ask for details such as your location, the location of the central point of presence, and your bandwidth requirements. They may also ask about your budget and any specific needs you have. Based on this information, the provider will provide a quote outlining the cost and service level options.
- **Negotiate and sign a contract:** If the quote is acceptable, you can begin negotiating the service level agreement terms and other contract details. This may include arranging the price, the length of the contract, and any penalties or termination fees [23]. Once both parties agree on the terms, you can sign the contract and make any required payments or deposits.
- **Install and test the service:** Once the contract is signed, the provider will install the necessary equipment to establish the backhaul connection. This may include installing fiber optic cables or installing microwave or satellite equipment. Once the installation is complete, the provider will test the service to ensure it meets the agreed-upon service level. This may include testing the bandwidth, latency, and uptime of the connection [23].
- **Monitor and maintain the service:** Once the backhaul connection is up and running, it's essential to monitor it regularly to ensure it continues to meet your requirements. This may involve monitoring bandwidth usage, network performance, and downtime or outages. The provider may also offer maintenance or support services to help you troubleshoot any issues or optimize the connection’s performance.

CHAPTER 4: COMMUNITY WIRELESS NETWORKS IN NORTHWEST TERRITORIES

4.1 Community Wireless Networks in Northwest Territories

Northwest Territories (NWT) is a sparsely populated northern Canada region facing unique challenges when providing reliable and affordable internet connectivity. The area has a significant Indigenous population, and many remote communities lack access to critical healthcare, education, and economic opportunities. In recent years, community wireless networks have emerged as a promising solution to bridge the digital divide and provide internet access to underserved communities in the NWT [24].

In the Northwest Territories (NWT), "community wireless networks" refers to developing local wireless communication networks run and managed by community members. These networks are independent of central authority. Residents of remote and isolated communities in the region can gain access to the Internet and other digital resources thanks to these networks, which connect them. In this analysis, we will investigate the current state of community wireless networks in the Northwest Territories, including their advantages and disadvantages, as well as statistical data that sheds light on how these networks are utilized and the effect that this has on the surrounding area.

Community wireless networks in the Northwest Territories respond to the lack of reliable internet connectivity in many of the region's remote and isolated communities. Many communities in the northern province of Canada do not have access to broadband internet, which contributes to the province having one of the country's lowest broadband penetration rates. Community wireless networks offer an alternative to conventional broadband infrastructure by granting communities the ability to construct and manage their networks [25].

The government of Canada has acknowledged that high-speed Internet infrastructure is essential to the promotion of economic growth and the accessibility of essential services such as healthcare and education, particularly in the northern regions of the country. All 33 communities in the Northwest Territories (NWT) now have access to high-speed Internet and 4G wireless connectivity thanks to the successful completion of the Northwest Territories (NWT) Broadband Infrastructure project [24], which is being celebrated by leaders from the federal government, the territorial government, community organizations, and the private sector. This project can drive innovation and economic development by enabling small businesses to broaden their customer base, improving access to healthcare services, and providing students with opportunities to further their education.

The project has implemented a variety of different measures to improve Internet delivery and bridge the gaps that were previously present. These include introducing satellite-based DSL internet services, upgraded usage package options, and advanced mobile internet (4G) service options. Residents of the Territory now have access to more advanced forms of multimedia applications, such as tele-education, video-conferencing, and online shopping, made possible by the increased speed of the Internet [24].

Table 2: Key telecommunications availability indicators (% of population for mobile services and % of households for Internet services) [26]

Type of Service	Subtype	2019	2020	2021	2022
Mobile broadband	HSPA+	99.4	99.4	99.5	99.5
	LTE	98.5	99.0	99.3	99.5
	LTE-A	83.0	92.0	94.9	96.0
Wireline broadband	DSL	77.0	72.3	70.4	83.9
	Cable modem	84.7	83.7	84.2	84.8
	FTTH	27.5	35.1	44.0	44.7
Wireline and fixed wireless	Total	98.4	98.7	98.8	98.9
Universal service objective	50 Mbps download, 10 Mbps upload, the unlimited-data transfer option	84.3	84.1	85.7	87.4
BDU services	IPTV	75.2 National	77.4	79.1	79.8
	Digital satellite		National	National	National

In 2022, there was a slight rise in the availability of fiber-based Internet service, which increased from 44.0% in 2021 to 44.7%. These FTTH deployments were mainly concentrated in large urban areas. Incumbent Telecommunications Service Providers (TSPs) utilized their fiber infrastructure to extend gigabit service to more than 6.9 million households. Cable-based carriers, on the other hand, primarily used DOCSIS 3.1 technology to provide gigabit service to over 6.5 million homes [26]. Nonetheless, fiber-based gigabit services are considerably quicker regarding upload speeds when compared to their DOCSIS-based equivalents.

The fiber-based Internet service availability increase, particularly in large urban areas, could affect community wireless networks in the Northwest Territories of Canada. While the Northwest Territories Broadband Infrastructure project has provided 4G wireless and high-speed Internet service to all 33 communities in the Territory, the availability of fiber-based internet service could offer even greater connectivity and faster upload speeds.

4.2 Current Status of Community Wireless Networks in NWT:

Several community wireless networks operate in NWT, serving urban and remote communities. These networks are typically run by local community organizations and volunteers and rely on a combination of grants, donations, and partnerships with local businesses and organizations to sustain their operations. Some of the critical community wireless networks operating in NWT include:

- **Hay River Community Wireless Network:** This network was established in 2008 and provided free wireless internet access to residents and visitors in Hay River, a small town on the south shore of Great Slave Lake. The Hay River Community Wireless Network is a grassroots initiative that local volunteers started to bridge the town's digital divide. The network was established using low-cost, off-the-shelf equipment and operated on a non-profit basis. Since its inception in 2008, the network has grown to include multiple access points throughout the town, allowing residents and visitors to access free wireless internet from various locations. The network has particularly benefited students and small business owners, who may need more resources to access high-speed internet through traditional means. The success of the Hay River Community Wireless Network has inspired similar initiatives in other small towns and rural communities throughout Canada and around the world. By providing free and accessible internet, these networks are helping to democratize

information and communication and promote greater social and economic inclusion [27] [25].

- **Inuvik Community Wireless Network:** This network was established in 2011 and provided free wireless internet access to residents and visitors in Inuvik, a town in the Mackenzie Delta region of NWT. The Inuvik Community Wireless Network is a community-driven initiative created to bridge the digital divide in the remote village of Inuvik. The network provides residents and visitors free internet access, which has become an essential service for remote communities in Canada. Since its establishment in 2011, the network has grown to include several access points throughout the town, making it easier for people to connect to the internet from various locations. The network has supported local businesses and promoted regional economic development by providing reliable internet access to entrepreneurs and startups. Overall, the Inuvik Community Wireless Network has become a valuable resource for the town, enabling more excellent connectivity and social inclusion for its residents.
- **Tlicho Online:** This network was established in 2012 and provides internet access to the Tlicho region, including four communities in the central part of NWT. Tlicho Online is a community-led project created to address the need for more reliable internet access in the Tlicho region of the Northwest Territories. The Tlicho region includes four remote communities - Behchoko, Gamèti, Wekweètì, and Whatì - which are located in the central part of NWT. The network, established in 2012, provides internet access to residents of these communities, enabling them to connect with the outside world and essential key to services like healthcare, education, and government programs.

  Tlicho Online is a shining example of how communities can address the digital divide and promote social and economic development in remote areas. Tlicho Online has become an essential tool for local businesses and entrepreneurs, enabling them to operate online and connect with customers outside the region. The network has also been instrumental in preserving the Tlicho language and culture by providing access to online resources and educational tools.

4.3 Introduction On the Northwest Tel

NORTHWESTEL INC

Northwest Tel Inc. is a Canadian telecommunications company that provides phone, internet, and television services to customers in the Northwest Territories, Nunavut, Yukon, and northern British Columbia. About community networks, there are several subtopics to explore:

- **Northwest Tel Inc. as a Local Carrier**: As a local carrier, Northwest Tel Inc. plays a significant role in providing communication services to the residents and businesses in the Northwest Territories. The company is responsible for maintaining the telecommunication infrastructure, which includes fiber optic networks, cell towers, and satellite services. In this context, Northwest Tel Inc. serves as a critical player in enabling access to the internet for the communities in the region [28].
- **Challenges in Internet Access:** Access to the internet is a critical issue in many parts of Canada, especially in remote and rural areas. The need for internet connectivity is a significant challenge for communities in the Northwest Territories. The vast distances, rugged terrain, and extreme weather conditions make building and maintaining the necessary infrastructure to provide reliable internet access d. Northwest Tel Inc. faces several challenges in providing internet services to these communities.

Collaboration between Northwest Tel Inc. and Community Networks:

A Community Wireless Network (CWN) is a network built and maintained by local community members to provide internet access to that community. These networks are often created in areas where traditional internet service providers are unavailable or expensive. In recent years, Northwest Tel Inc. has worked with community networks to improve internet access in the Northwest Territories. The company has partnered with local organizations to fund and support community network initiatives. For example, in 2019, Northwest Tel Inc. and the Canadian Internet Registration Authority (CIRA) funded the Northwest Territories' first community-owned internet service provider.

Northwest Tel and Community Wireless Networks:

- **Accessibility:** The Northwest Territories and Nunavut are sparsely populated and have a challenging geography, which makes it difficult for traditional telecommunications companies like Northwest Tel to provide internet access to all communities in the region. Community wireless networks can be a valuable addition

to Northwest Tel's services, as they can help bridge the connectivity gap and provide internet access to underserved areas [29].

- **Collaboration:** Northwest Tel has previously worked with community wireless network groups to help connect remote communities in the region. In 2017, Northwest Tel partnered with the Northwest Tel Community Investment Fund to fund community wireless network initiatives. This collaboration has helped provide internet access to more people in the region.
- **Competition:** Community wireless networks can also pose a potential threat to Northwest Tel's business, as they may offer cheaper or more accessible internet options to consumers [29]. However, Northwest Tel can also work with these networks to provide additional services or support, which can help mitigate the impact of competition.
- **Innovation:** Community wireless networks can also be a source of innovation and experimentation for Northwest Tel, as they often employ creative and unique solutions to provide internet access to communities [29]. By working with these networks, Northwest Tel can gain insights into new technologies or approaches that could be applied to its services.
- **Future of Internet Access in the Northwest Territories:** The demand for high-speed internet services in the Northwest Territories is expected to increase in the coming years. To meet this demand, Northwest Tel Inc. and community networks will need to work together to expand internet access and improve the quality of service. Collaboration between the two will be critical in ensuring that residents and businesses in the region can access reliable, affordable internet services.
- **Broadband Expansion:** The Canadian government has set a goal of providing universal access to high-speed internet by 2030. The government has committed to investing in broadband infrastructure in rural and remote areas as part of this initiative. Northwest Tel Inc. has received funding from the government to expand broadband services in the Northwest Territories. The company is working on a project to build a fiber optic network connecting several regional communities to high-speed internet [29].
- **Digital Divide:** The lack of internet access in many parts of Canada has led to a digital divide between urban and rural areas. This divide has significant economic, social, and educational implications, as people in rural areas often cannot access the same opportunities as those in urban areas. Northwest Tel Inc. and community

networks are working to bridge this divide by expanding internet access in remote and rural communities.

- **Indigenous Communities:** The Northwest Territories is home to many Indigenous communities, and improving internet access in these communities is a priority for both Northwest Tel Inc. and community networks. The lack of internet access in Indigenous communities significantly impacts their ability to access education, healthcare, and economic opportunities. Northwest Tel Inc. and community networks are working with Indigenous leaders to improve internet access and ensure their communities are included in the digital age [29].
- **Telehealth and Tele-education:** Telehealth and Tele-education are two areas that could benefit significantly from improved internet access in the Northwest Territories. Telehealth services, which allow patients to consult with healthcare providers remotely, could be a game-changer for people living in remote communities. Similarly, Tele-education services, which provide online learning opportunities, could help to improve educational outcomes in the region. Northwest Tel Inc. and community networks are working on expanding internet access to make these services more accessible to people in remote communities.
- **Future Technologies:** As technology evolves, the demand for high-speed internet services will only increase. New technologies such as 5G, the Internet of Things (IoT), and artificial intelligence (AI) will require faster and more reliable internet connections in the coming years. Northwest Tel Inc. and community networks must continue investing in infrastructure to keep up with these developments and ensure their communities are included.

In addition to the broader context, there are also technical aspects to consider about Northwest Tel Inc. and community networks:

- **Infrastructure:** The technical infrastructure required to provide internet services in the Northwest Territories is complex and challenging. Building and maintaining fiber optic networks, cell towers, and satellite services in remote and rugged terrain requires specialized equipment and skilled personnel [30]. Northwest Tel Inc. has invested heavily in infrastructure, but the cost of building and maintaining it is high.
- **Bandwidth:** The bandwidth available to internet users in the Northwest Territories is often limited due to the technical limitations of the infrastructure. This can lead to slow internet speeds and poor quality of service. Northwest Tel Inc. and community

networks need to balance the demand for bandwidth with the capacity of the infrastructure to ensure that users have access to reliable internet services.

- **Latency:** The time data travels from a user's device to the internet and back. In remote areas, latency can be high due to the long distances data travels. This can lead to slow internet speeds and poor quality of service [30]. Northwest Tel Inc. and community networks need to optimize their infrastructure to minimize latency and improve the quality of service.
- **Wireless Connectivity:** Wireless connectivity is a critical aspect of internet access in the Northwest Territories. Cell towers and satellite services are often the only means of providing internet access to remote communities. Northwest Tel Inc. and community networks need to balance the demand for wireless connectivity with the technical limitations of the infrastructure to ensure that users have access to reliable internet services.
- **Cybersecurity:** Cybersecurity is a critical aspect of internet access in the Northwest Territories. As more people use the internet to access sensitive information, such as healthcare and financial data, the risk of cyber-attacks increases. Northwest Tel Inc. and community networks must ensure that their infrastructure is secure and that users can access tools and information to protect themselves from cyber threats.

  Overall, providing internet access in the Northwest Territories is a complex and challenging task that requires significant investment in technical infrastructure and expertise. Northwest Tel Inc. and community networks are working to address the technical challenges of providing reliable, high-speed internet services to remote communities in the region.

4.4 Comparison of Acceptable Use Policies for Community Wireless Networks in Northwest Territories with other Regions in Canada)

Acceptable Use Policies (AUPs) in Community Wireless Networks (CWNs) in the Northwest Territories (NWT) are similar to those in other regions in Canada, but there are some differences. Regarding similarities, AUPs in CWNs across Canada aim to promote responsible and ethical network use and prevent illegal or harmful activities, such as spamming, hacking, or sharing copyrighted materials without permission. They also often emphasize respecting others' privacy and not engaging in discriminatory behavior or harassment [31].

However, AUPs in NWT CWNs may differ in terms of their specific rules and guidelines, as they may be tailored to the unique needs and characteristics of the region. For example, there may be restrictions or policies regarding bandwidth usage or network access in specific locations or certain times of the day. AUPs in NWT CWNs may also emphasize preserving the local communities' cultural identity and language. While there may be regional variations in AUPs in CWNs across Canada, their underlying goals and principles are generally similar**.**

In addition to the similarities and differences mentioned, it is worth noting that AUPs in CWNs across Canada are often developed with input and feedback from community members and other stakeholders. This collaborative approach can help ensure that the policies are effective and reflect the needs and values of the local community. Furthermore, AUPs in CWNs can be essential in promoting digital literacy and responsible use of technology. By outlining expectations for behavior and providing resources and guidance for safe and ethical online practices, AUPs can help equip users with the knowledge and skills they need to navigate the digital world responsibly and productively. Finally, it is essential to recognize that AUPs are not the only mechanism for promoting the responsible use of CWNs. Other strategies, such as user education and community outreach, can also play an essential role in fostering positive online behavior and preventing harmful activities. Ultimately, a multi-faceted approach that combines policies, education, and community engagement is likely to be the most effective way to ensure the safe and responsible use of CWNs in communities across Canada [31].

4.5 Challenges and Opportunities:

While community wireless networks in NWT have made significant strides in expanding internet access and promoting digital equity, they still face several challenges and opportunities for improvement. Some of the critical challenges and opportunities for community wireless networks in NWT include the following:

- **Limited Technical Expertise:** Many community wireless networks in NWT are run by volunteers who may need more technical expertise or resources to maintain and expand the web effectively. Despite the many benefits of community wireless networks in NWT, one of the significant challenges faced by these networks is the limited technical expertise and resources available to maintain and expand them. Many of these networks are run by volunteers with little experience in network

administration, making it challenging to address technical issues or plan for future expansion [32].

- Despite these challenges, community wireless networks remain vital for promoting connectivity and social inclusion in NWT. Furthermore, the remote and harsh environment in which these networks operate can present additional challenges, such as extreme weather conditions, limited electricity access, and technical support. As a result, community wireless networks in NWT often require creative solutions and innovative approaches to overcome these challenges. To address these challenges, some communities have sought partnerships with local and national organizations to provide technical support and resources. Others have invested in training programs to empower residents with the skills to maintain and expand the network.
- **Funding:** Community wireless networks in NWT often rely on grants, donations, and partnerships with local businesses and organizations to sustain their operations, which can be challenging in the long term. Funding is another significant challenge faced by community wireless networks in NWT. These networks often rely on a mix of grants, donations, and partnerships with local businesses and organizations to sustain their operations, which can be challenging in the long term.

  Grants and donations are often limited in scope and duration, making planning for the network's long-term sustainability difficult. Moreover, many communities in NWT have limited economic resources, making it challenging to secure the necessary financial resources to operate and maintain a community wireless network. To address these challenges, some communities have developed innovative funding models, such as community-led crowdfunding campaigns or revenue-generating initiatives, to sustain their operations. Others have sought partnerships with local and national organizations to secure funding and resources. Despite these challenges, community wireless networks in NWT remain essential for promoting connectivity and social inclusion in remote communities. These networks have the potential to provide vital services and support economic development, making them a valuable investment for both local communities and broader society [32].
- **Connectivity:** While community wireless networks have played a crucial role in expanding internet access in NWT, many remote and underserved communities still lack access to reliable and affordable internet connectivity. These communities often need help with connectivity, such as high costs of infrastructure development and limited or no access to traditional internet service providers.

The lack of connectivity in these communities can have significant social and economic impacts, limiting access to essential services, educational resources, and economic opportunities. Moreover, the COVID-19 pandemic has highlighted the urgent need for reliable and affordable internet access, as many benefits have shifted online. To address these challenges, some communities in NWT are exploring innovative approaches to expanding connectivity, such as community-led satellite internet projects and partnerships with local and national organizations to provide technical support and resources. Additionally, the Canadian government has significantly invested in expanding internet access nationwide, including in remote and underserved communities in NWT. Despite the challenges of developing connectivity in remote areas, there is growing recognition of the importance of digital infrastructure as a vital tool for promoting social and economic development. Through sustained effort and collaboration, it is hoped that all communities in NWT will be able to access reliable and affordable internet connectivity shortly [32].

In addition to challenges related to connectivity, another issue faced by residents in NWT is the need for digital literacy skills.

- **Digital Literacy**: Many residents in NWT may need more digital literacy skills, which can effectively impact their ability to use and benefit from internet connectivity. Many residents may need access to digital technology daily and require more skills to use and benefit from internet connectivity. This can create barriers to accessing essential services and information online and pursuing educational and economic opportunities [32]. To address this issue, some communities in NWT are investing in digital literacy training programs to help residents develop the skills they need to use digital technology and the internet effectively. These programs can be critical in promoting digital inclusion and enabling residents to take full advantage of the many benefits of internet connectivity.
- **Scalability:** As community wireless networks in NWT grow and more users come online, network capacity and performance may be challenging, which can impact the quality of service for users. As community wireless networks in NWT grow and more users come online, network capacity and performance may have challenges. Community wireless networks often rely on shared resources and may have different power and redundancy than traditional internet service providers. As a result, as the number of users on the network increases, there may be issues with network

congestion, reduced speeds, and decreased reliability, which can impact the quality of service for users.

- To address these challenges, community wireless networks in NWT must carefully plan for growth and work to optimize network performance through a range of strategies, such as upgrading network infrastructure, implementing Quality of Service (quality of service) mechanisms, and implementing fair usage policies to ensure that all users have equitable access to network resources. Moreover, partnerships with local and national organizations can provide technical expertise and resources to help community wireless networks in NWT scale effectively and sustainably, ensuring that all residents can access high-quality, reliable internet connectivity now and into the Future [32].

4.6 Policy and Regulatory Considerations:

To address these challenges and opportunities, policymakers, regulators, and other stakeholders must work together to support the development and success of community wireless networks in NWT. This may involve developing policies and regulations supporting community wireless networks' growth, such as funding programs, technical support, and capacity-building initiatives. Additionally, policymakers and regulators can work to ensure that community wireless networks in NWT have access to adequate spectrum and can comply with relevant regulations and standards.

4.7 Community Engagement and Ownership:

One of the critical strengths of community wireless networks in NWT is their strong focus on community engagement and ownership. These networks are typically run by local community organizations and volunteers, who work closely with residents to identify their needs and design solutions tailored to their unique circumstances. This approach has helped to build solid relationships and trust between community members and the network operators and has created a sense of ownership and pride in the network. In addition, community wireless networks in NWT often rely on local volunteers to help install and maintain the network infrastructure. This helps reduce costs and build local capacity and expertise, which can be valuable in supporting the network's long-term sustainability.

4.8 Technology and Infrastructure:

Community wireless networks in NWT use various technologies and infrastructure to provide internet connectivity to users. This can include mesh networks, which allow for creating a network of nodes that can communicate with each other and route traffic between them, and point-to-point connections, which use directional antennas to connect two or more locations. In addition to the technology used, the infrastructure required to support community wireless networks can vary depending on the location and terrain of the community. In some cases, this may involve the installation of towers or other tall structures to provide line-of-sight connectivity between different locations. In other cases, it may include using existing infrastructure, such as power lines or buildings, to mount antennas and other equipment.

4.9 Partnerships and Collaboration:

Community wireless networks in NWT often rely on partnerships and collaboration with various stakeholders to sustain their operations. This can include partnerships with local businesses and organizations to provide funding or other resources and cooperation with government agencies and regulators to ensure compliance with relevant regulations and standards. In addition, community wireless networks in NWT often collaborate with other networks and organizations to share knowledge, expertise, and resources. For example, the Hay River Community Wireless Network is a member of the National Capital Freenet, a community wireless network in Ottawa. It has benefited from their technical expertise and support.

4.10 Information about Community Wireless Networks in the Northwest Territories

According to statistics, 85% of households in the area had access to broadband Internet, according to 2018 research by the Canadian Radio-television and Telecommunications Commission (CRTC), even though there is not much statistical data on community wireless networks in the Northwest Territories. This proportion exceeds the 82% national average. It is crucial to remember that this information does not describe the caliber or speed of a home's internet connection; instead, it merely shows if a household has access to broadband Internet. Also, remote and secluded areas may have substantially less access to the internet [33].

Initiating a review of its regulatory framework for Northwestel Ltd. and the telecommunication services offered in Canada's North, the Canadian Radio-television and Telecommunications Commission (CRTC) has opened a consultation process to gather

feedback from the general public. In the Yukon, the Northwest Territories, Nunavut, northern British Columbia, and Fort Fitzgerald, Alberta, Northwestel serves 96 settlements as the principal telecommunications service provider in the area.

Through its Communications Monitoring Report, the CRTC disseminates comprehensive information on the state of Canadian telecommunications systems. The CRTC is considering using public opinion research to supplement its current statistics to comprehend the demands of Canadian citizens in Canada's north. The objective is to solve potential problems with the caliber, accessibility, and cost of telecommunications services.

Environics conducted focus groups with locals in the regions served by Northwestel, which include Yukon, the Northwest Territories, Nunavut, and northern British Columbia, as well as several omnibus questions with a quantitative approach in their North of 60° and Remote Community Monitor as part of this research [33].

Indeed, Assessing the significance that telecommunications services play in the lives of Canadians living in Canada's North and determining whether the telecommunications services currently on the market satisfy those demands were the research's two key goals.

Table 3: Services Paid for in Households [33]

Service	**Total (n=1000)**	**Yukon (n=275)**	**Northwest Territories (n=350)**	**Nunavut (n=275)**	**Nunavik (n=70)**	**Labrador/ Nunatsiavut (n=30)**
Home telephone/landline	95%	96%	95%	93%	94%	77%
Home Internet access	86%	93%	85%	80%	80%	90%
Cell phone	78%	82%	86%	82%	26%	81%

Northwestel, a leading provider of residential Internet access, is the market leader in this area. Residents in the North who have access to home internet were surveyed and questioned about their internet service provider. Almost 65% of locals said Northwestel is their internet service provider. Other providers serve less than 10% of residents. The top internet service provider differs per location, however. With percentages of 88% and 90%, respectively, people of Yukon and the Northwest Territories claimed that Northwestel is their internet service

provider. On the other hand, SSi is the primary provider in Nunavut for 39% of residents, and Tamaani is the top provider in Nunavik for 51% of residents.

Indigenous individuals are less likely than non-Indigenous persons to use Northwestel as their internet service provider and more likely to utilize alternative providers. This is because they comprise a more significant portion of the population in areas with different internet service providers (such as Nunavut, Nunavik, and Labrador). In Yukon and the Northwest Territories, where Northwestel is the only provider, they comprise a far smaller proportion of the population.

Table 4: Subsample for Home Internet access with Home Internet provider [33]

Subsample: Those with home Internet access

Source	Total (n=870)	Yukon (n=253)	Northwest Territories (n=302)	Nunavut (n=229)	Nunavik (n=59)
Northwestel	65%	88%	90%	25%	<1%
SSi Micro / Qiniq / Yellowknife	9%	<1%	<1%	39%	3%
Bell	8%	5%	4%	14%	3%
Xplornet	4%	2%	*%	7%	24%
Tamaani	4%	-	-	-	51%
Other	4%	1%	2%	4%	8%
Do not know	5%	3%	3%	11%	12%

Internet access method

The most common ways northerners access the internet are through cable or DSL. Cable internet, used by 34% of customers, DSL by 33%, and satellite internet by 19% are the three

most popular ways to obtain home internet service. Depending on the size of the municipality, different people can use the Internet, with cable internet accounting for 58% of users in larger cities. In contrast, smaller towns frequently rely more on satellite internet (31%) or DSL through a phone line (43%). Due to variations in population size, these location-related variances also impact internet access depending on identification. While non-Indigenous people use cable internet more frequently, Indigenous people use satellite internet more regularly [33].

Table 5: Method of Internet service [33]

Subsample: Those with selected Internet providers

Method	Total (n=770)	Yukon (n=245)	Northwest Territories (n=290)	Nunavut (n=201)
Cable Internet	34%	44%	43%	5%
DSL through a telephone line	33%	40%	34%	20%
Satellite Internet	19%	4%	3%	64%
Fibre Internet	9%	8%	14%	1%
Fixed wireless Internet	<1%	-	-	<1%
Do not know	6%	4%	6%	9%

4.11 Community Wireless Networks' Effect on Area

In remote and underdeveloped areas, community wireless networks have become a potent tool for enhancing residents' quality of life. There are numerous anecdotal stories of favorable outcomes, even though it is difficult to measure the impact of these networks. In Fort Liard, for instance, developing a community wireless network has resulted in greater accessibility to healthcare services. Residents can obtain medical attention and consultations remotely. As a

result, they are greatly enhancing healthcare outcomes. This is crucial in rural areas with limited access to healthcare, where patients may have to travel great distances to receive care. Community wireless networks have significantly impacted economic growth, education, and healthcare [34]. These networks have allowed inhabitants of many communities to receive online education and training, improving their knowledge and abilities. In turn, this has expanded residents' opportunities and fueled economic growth.

Furthermore, dependable internet connectivity has boosted the growth of small businesses and entrepreneurship. For instance, several towns have developed online marketplaces and e-commerce platforms using their wireless networks, allowing local companies to reach a more extensive clientele and broaden their reach. In conclusion, although it is challenging to quantify the specific effects of community wireless networks on the area, there is undeniable proof of their beneficial effects. These networks have developed into a crucial instrument for improving the quality of life for individuals in rural and underserved places, from enhanced healthcare access to expanded economic prospects.

4.12 Initiatives by the Government and Non-Profits to Encourage Neighborhood Wireless Networks

The Canadian government and non-profit groups have started many efforts to aid in growing community wireless networks in the Northwest Territories. For instance, the CRTC has established a fund to encourage broadband infrastructure initiatives in remote and rural areas, including community-led projects. Projects for community wireless networks are supported technically and financially by the First Mile Connectivity Consortium. On the other hand, the Northern Aboriginal Broadcasting program aids Native American communities in establishing local media and communication initiatives.

4.13 Future of Wireless Networks in Communities in the Northwest Territories

Community wireless networks appear to have a bright future in the Northwest Territories. The need for dependable and reasonably priced connectivity will only increase as internet access becomes more and more essential for daily living. Community wireless networks offer an affordable answer for isolated and underdeveloped areas where standard internet infrastructure is not possible or practicable.

We anticipate expanding and developing community wireless networks in the Northwest Territories to continue. To guarantee that all inhabitants have access to high-quality internet services, the territorial government, neighborhood associations, and private businesses are

expected to continue to invest in enhancing and expanding these networks. Enhancing community wireless networks' speed and capacity may be one focus area. Demand for faster and more reliable connections will only rise as more people rely on the Internet for business, education, and pleasure. Community wireless networks must upgrade existing infrastructure and incorporate new technologies to accommodate this demand for faster and more dependable connectivity.

Also, we can anticipate seeing more avant-garde applications of community wireless networks, such as the expansion of e-commerce and digital marketplaces and the application of smart city technology. By making services and resources more readily available, these projects will increase prospects for economic growth and development while also enhancing the quality of life for locals. The Northwest Territories community wireless networks have a promising future. As these networks develop and expand, they will become more crucial in tying together communities, boosting economic prospects, and elevating locals' living standards.

4.14 Northwest Territories Internet Access Comparison Between Urban and Rural Areas

Just 39% of homes in the Northwest Territories have access to internet speeds that fulfill the CRTC's definition of an essential service, according to a 2019 Canadian Internet Registration Authority (CIRA) report (50 Mbps download and 10 Mbps upload). In Canada's urban areas, 97% of households are similar to this. The survey also revealed that internet access costs are significantly higher in the Northwest Territories than in urban regions.

In the Northwest Territories, there are substantial differences between urban and rural regions regarding the accessibility and caliber of broadband service. In contrast to rural towns, which frequently rely on cellular data services, satellite internet, or community wireless networks, urban areas typically have access to high-speed Internet via traditional broadband infrastructure. Residents of urban regions have access to high-speed Internet via cable or fiber-optic connections, ranging from 50 Mbps to more than 1 Gbps [35]. They now have quick and dependable access to various internet resources, such as video streaming, online gaming, remote job, and distance learning.

In contrast, the Northwest Territories rural settlements frequently lack access to typical internet infrastructure. Due to the high cost of constructing and maintaining the required infrastructure in these areas and the low population density, internet service providers cannot

afford to invest in building broadband infrastructure [35]. Several isolated towns have turned to community wireless networks, which use point-to-point wireless technology to connect homes and businesses to the Internet, to close this gap in broadband availability. Although these networks are typically slower than conventional broadband connections, they offer a practical way to bring internet access to remote locations.

You can also get cell phone data services and satellite internet in specific isolated communities. However, the cost of these services and possible data caps can deter online access. Overall, the Northwest Territories' disparities in broadband connectivity between urban and rural areas show the difficulties in granting everyone access to high-speed internet services. While dependable and quick Internet is available in urban areas, isolated populations have substantial access challenges. Community-driven solutions like community wireless networks need to address this digital divide.

4.15 Usage Statistics for Community Wireless Networks in the Northwest Territories

Community wireless networks in the Northwest Territories are used for various purposes, including education, healthcare, social networking, and more. While there is limited data available on the usage of these networks, a 2019 report by the First Mile Connectivity Consortium provides some insights into the benefits and applications of community wireless networks in the region.

According to the report, community wireless networks are used for telehealth services, enabling remote consultations and diagnoses and improving healthcare outcomes for residents in remote and underserved areas. In addition, community wireless networks have been used to provide access to online education and training, enabling residents to acquire new skills and improve their employment prospects. The networks have also facilitated social networking and communication, allowing the residents to connect with friends and family members in other parts of the region and the world.

Another significant benefit of community wireless networks is their ability to foster community engagement and participation. The report found that community members are actively involved in the design and operation of the networks, which has led to a sense of ownership and community pride. This involvement has also enabled community members to

learn new technical skills and gain experience in network management, which has created new opportunities for employment and entrepreneurship.

While there is limited data on community wireless networks in the Northwest Territories, the available information suggests that these networks significantly benefit residents in remote and underserved areas. From enabling telehealth services to fostering community engagement and participation, community wireless networks play an essential role in connecting communities and improving the quality of life for residents in the region.

CHAPTER 5: LICENSING POLICIES AND REGULATIONS IN SOUTH AFRICA AND KENYA

Policies and regulations about licensing are an essential component of any community, as they promote compliance, accountability, and the efficient delivery of services. In Kenya and South Africa, licensing policies and regulations play an essential role in regulating businesses, ensuring public safety, and fostering economic expansion. This discussion will examine the licensing policies and regulations for the Kenya and South African communities.

5.1 Licensing Policies and Regulations for Communities in Kenya

In Kenya, policy and regulatory frameworks refer to the guidelines and laws that are in place to govern the development, implementation, and enforcement of policies and regulations across different sectors and industries. These frameworks ensure policies are well-structured, effective, and aligned with national goals and objectives. At the same time, rules aim to promote compliance with established standards and best practices to safeguard the public interest. The government is responsible for formulating and implementing these frameworks, with the support of various stakeholders and regulatory bodies, to ensure that the needs of the citizens and the country are met. The regulatory framework includes the following:

Broadband Policy, Legal and Regulatory Environment under NBS

The strategy identifies several policies, regulations, and legislation yet to be implemented to enhance the broadband sector's enabling environment. One of these policies is centered around infrastructure and covers affordability, the recognition of broadband as critical infrastructure, spectrum management, and rural broadband infrastructure. The strategic actions to be taken under this policy are:

- Infrastructure sharing
- New legislation designates broadband as a necessary infrastructure.
- Spectrum refarming involves repurposing spectrum bands for more efficient technologies or new services.
- The strategy proposes establishing regulations for Public-Private Partnerships (PPP) in the broadband sector, allowing infrastructure operators in rural areas to provide services to multiple mobile network operators.
- The strategy aims to collaborate with various partners to initiate projects that target connecting those who are unconnected or under-connected, particularly in rural and remote areas. One such initiative involves using High Altitude Platform Stations (HAPS) to provide cost-effective, fast, and adaptable backhaul broadband services

and also serve as a vital link for emergency communication during natural disasters. Additionally, the strategy outlines specific focus areas on laws and regulations and proposes the following regulatory actions:

5.2 Licensing and Authorization

The strategy proposes to improve the efficiency of local licensing processes and reduce entry barriers to expedite the deployment of connectivity infrastructure at a lower cost. The plan also aims to open up rights of way and access to facilities, eliminate obstacles to passive infrastructure sharing, and promote competition [36].

Spectrum management

- The strategy aims to promote efficient spectrum utilization by regularly reassessing spectrum allocations, lowering entry barriers for service providers, and promoting competition.
- The strategy proposes flexible spectrum policies that permit adaptable spectrum sharing and utilization in underserved or unserved areas.
- The strategy aims to implement spectrum policies that support both licensed and unlicensed spectrum allocations.
- The strategy proposes policies that support networks' coverage and capacity, particularly in underserved areas and for underserved populations.

Open Access

The strategy defines open access as the opportunity for third parties to utilize an established network infrastructure to provide services, primarily in areas where economic constraints obstruct competitive supply and publicly funded national broadband networks exist. The strategy notes consensus on open access to national broadband infrastructure. Therefore, the proposed regulatory action aims to promote equitable, reasonable, and non-discriminatory access to broadband networks, particularly in cases where public funding has been used for rollout.

The 2006 National ICT policy was reviewed in 2019 to ensure its relevance to the fast-paced technological advancements, legal and administrative changes, and emerging trends. Concerning broadband network deployment and access, the policy asserts that:

5.3 Kenya National Broadband Strategy

It is the goal of Kenya's national broadband strategy for 2018 to transform the country into a knowledge-based society that can compete successfully on a global scale by improving access to affordable, secure, and speedy broadband. According to the strategy, broadband is defined as connectivity that is accessible, interactive, safe, and of high quality and that provides a minimum speed of 2 Mbps to every user in Kenya. The system detects gaps in technical and related capacity for broadband and encourages peer-to-peer learning opportunities through a national community networks development program in conjunction with key partners. In addition, the system identifies gaps in technical and related capacity for wireless broadband. The program will give new community networks assistance, coaching, and handholding to develop abilities and innovations in the broadband space. The broadband strategy also supports the creation of methods to boost local enterprises' adoption of information and communications technologies (ICTs) through community-led initiatives, particularly in rural and underserved areas. Last, the plan calls for additional broadband investment models, such as the "Bottom-up strategy citizen model." This model involves end-users organizing themselves into a jointly owned and democratically controlled group that can supervise the contract to build and operate their local broadband network.

A democratic method of delivering affordable internet connection to communities, including homes, companies, schools, and hospitals, can be accomplished through community networks that offer this method. Regular consultations between all parties involved should take place in the form of in-person town hall meetings, online forums such as webinars, and email lists such as the KICTANet [36]list. These consultations aim to investigate ways to implement these recommendations and expand the reach of community networks. Community networks need access to public money like the CDF, USF, and the budgets of county governments. Community networks should be encouraged by the adoption of favorable policies by governments. These policies should include the provision of access to wayleaves, the promotion of infrastructure sharing, and the provision of tax relief to community network operators.

5.4 Licensing Policies and Regulations in South Africa

Licensing policies and regulations in South Africa for community wireless networks are governed by the Independent Communications Authority of South Africa (ICASA) [37]. To operate a community wireless network in South Africa, an organization must apply for a

license from ICASA and comply with various regulations and guidelines. One of the critical regulations that community wireless networks must comply with is obtaining a spectrum license from ICASA. This license is necessary to use radio frequencies for wireless communication. Community wireless networks must also comply with various technical standards, such as radio interference and network security.

In addition to these technical regulations, community wireless networks must comply with various legal content and service provision requirements. For example, ICASA requires community wireless networks to provide access to emergency services and comply with data protection and privacy regulations. Regarding licensing policies and regulations related to content provision, community wireless networks in South Africa are subject to the same rules and regulations as other broadcasters and content providers. This means they must comply with copyright law, which governs the use and distribution of copyrighted works, such as music, movies, and other media [37].

To ensure compliance with copyright law, community wireless networks must obtain the necessary permissions and licenses from copyright owners before broadcasting or distributing their works. They may also be required to pay royalties or other fees to use copyrighted content. Overall, licensing policies and regulations in South Africa for community wireless networks are designed to ensure that these networks operate safely, securely, and legally compliant. By complying with these regulations and guidelines, community wireless networks can provide valuable services to their communities while ensuring that they operate within the bounds of the law. South Africa has several policy and legislative elements pertinent to the community network (CN) model. Some of these include:

- **The National Integrated ICT Policy White Paper:** The National Integrated ICT Policy White Paper, published by the South African government in 2016, is a comprehensive policy document providing a roadmap for developing the country's information and communications technology (ICT) sector. The policy aims to promote the sector's growth inclusively and equitably so that all South Africans can access the benefits of the digital economy.

  One of the critical goals of the policy is to promote universal access to affordable and reliable broadband services. The approach recognizes that broadband access is essential for economic growth, social inclusion, and civic participation and that broadband access is necessary for many South Africans to be included in the benefits

of the digital economy. The policy, therefore, sets out a range of interventions to promote universal access to broadband, including promoting community networks.

Community networks are recognized as an essential means of achieving universal access to broadband services, particularly in underserved areas where commercial providers are often unwilling or unable to invest. The policy recognizes the potential of community networks to provide affordable, high-quality broadband services to these areas and encourages the development of community network initiatives.

The policy also recognizes that community networks can promote digital inclusion and empower local communities. By involving local communities in the design, deployment, and operation of broadband networks, community networks can help to build capacity and skills, create new opportunities for local businesses and entrepreneurs, and promote social and civic participation.

Overall, the National Integrated ICT Policy White Paper provides a robust policy framework for developing community networks in South Africa. By emphasizing the need to promote universal access to affordable and reliable broadband services and recognizing the role that community networks can play in achieving this goal, the policy provides an essential foundation for the growth and development of community network initiatives in the country.

- **The Electronic Communications Act:** This legislation is the Electronic Communications Act of 2005, enacted in South Africa to regulate the provision of electronic communications services in the country. The Act sets out the legal and regulatory framework for the electronic communications sector, including establishing the Independent Communications Authority of South Africa (ICASA) as the regulator for the industry.

  Under the Act, ICASA licenses electronic communications services in South Africa. The Act provides for the licensing of individual electronic communications services and networks. This includes licensing community networks established and operated by communities for their benefit.

  The Act also sets out the rights and obligations of electronic communications service providers, including requirements to provide certain services, protect their customers' data privacy, and comply with specific technical standards.

  Overall, the Electronic Communications Act of 2005 provides a comprehensive framework for regulating electronic communications services in South Africa and has played an essential role in promoting competition, innovation, and growth in the

sector. One of the key aims of the Act is to encourage competition in the electronic communications sector in South Africa. To this end, it includes provisions for regulating anti-competitive conduct by service providers and promoting new market entrants.

- **The National Broadband Policy**: In 2020, the South African government released the National Broadband Policy to provide all citizens with affordable, high-speed broadband connectivity. The policy recognizes the importance of community networks to achieve universal access to broadband services, particularly in underserved areas.

  The National Broadband Policy acknowledges that community networks can play a critical role in providing affordable and reliable broadband services to communities that traditional telecommunications providers often leave behind. The policy encourages the development and growth of community networks to increase broadband access and promote digital inclusion across South Africa. To support the development of community networks, the National Broadband Policy sets out several specific measures, including the allocation of radio frequency spectrum for community networks and the establishment of a dedicated fund to support their development.

  Overall, the National Broadband Policy represents an essential step towards achieving universal access to broadband services in South Africa and recognizes the critical role that community networks can play in making this a reality. By supporting the growth and development of community networks, the policy has the potential to bring affordable, high-speed internet access to even the most remote and underserved communities [37].
- **The National Radio Frequency Plan**: This plan, developed by ICASA, provides a framework for allocating and managing the radio frequency spectrum in South Africa. Community networks must comply with the requirements of this plan when using radio frequency spectrum for their wireless communication services.
- **The Community Broadcasting Services Regulations:** These regulations, published by ICASA, govern the provision of community broadcasting services, including community networks that provide broadcasting services. The rules set out requirements for licensing, technical standards, content provision, and other operational aspects of community broadcasting services.

5.5 ICASA (The Independent Communications Authority of South Africa) on Licensing and Various Regulations

The Independent Communications Authority of South Africa, or ICASA, is responsible for monitoring the licensing and management of the country's telecom sector. ICASA is a Chapter 9 organization that promotes democracy and falls under the Department of Communications (DoC) purview. In July 2000, the South African Telecommunications Regulatory Authority (SATRA) and Broadcasting Authority (IBA) merged to form the Independent Communication Authority of South Africa (ICASA) by the Independent Communication Authority of South Africa Amendment Act of 2000. Later in 2005, the same primary was changed to add the Postal Regulator to ICASA and raise the number of councilors on its council from seven to nine. The primary duty of ICASA is to oversee the telecommunications, broadcasting, and postal industries in South Africa, making sure that the public is provided with services that are both inexpensive and of high quality. The Authority grants licenses to service providers, upholds regulations' compliance, guards against deceptive business practices and poor customer service, hears and resolves complaints and disputes, and efficiently supervises the use of the radio frequency spectrum. Other regulatory authorities, such as the Communications Authority of Kenya (CAK) and South Africa, oversee the telecommunications sector in other African nations

5.5.1 Licensing:

ICASA is responsible for issuing licenses to telecommunications operators in South Africa. ICASA issues permit for various telecommunications services, including fixed-line, mobile, broadband, and internet services. The process of obtaining a license is rigorous and requires operators to demonstrate their technical, financial, and managerial capabilities and compliance with local regulations. The licensing fees charged by ICASA can be significant, making it difficult for smaller operators to enter the market.

The CAK also issues licenses to telecommunications operators in Kenya. Like ICASA, the CAK requires operators to demonstrate their technical, financial, and managerial capabilities and compliance with local regulations. The CAK issues licenses for various telecommunications services, including fixed-line, mobile, and broadband internet services. The licensing fees charged by the CAK can be significant, making it difficult for smaller operators to enter the market.

5.5.2 Regulations:

ICASA and the CAK are responsible for setting and enforcing regulations in the telecommunications industry in South Africa and Kenya, respectively. These regulations cover many issues, including interconnection, quality of service, consumer protection, and competition.

- Interconnection: ICASA and the CAK require telecommunications operators to interconnect their networks to enable users to communicate with each other regardless of their operator. This helps to promote competition and ensure that users have a wide range of services to choose from.
- Quality of service: ICASA and the CAK set standards for the quality of service that telecommunications operators must provide. This includes requirements for network availability, call completion rates, and network latency. Operators that fail to meet these standards can face penalties and fines.
- Consumer protection: ICASA and the CAK have regulations to protect consumers from fraud, deceptive marketing, and other unfair practices. This includes rules around billing, advertising, and providing information to consumers.
- Competition: ICASA and the CAK have regulations to promote competition in the telecommunications industry. This includes requirements for operators to provide access to their networks and services on fair and non-discriminatory terms and rules around mergers and acquisitions that could impact competition.

In conclusion, ICASA and the CAK are essential in regulating the telecommunications industry in South Africa and Kenya, respectively. They issue licenses to operators, set and enforce regulations, and promote competition in the industry. While these regulations are essential for protecting consumers and promoting fair competition, the high licensing fees and stringent requirements can make it difficult for smaller operators to enter the market.

5.6 Comparison of Licensing Policies and Regulations in Kenya and South Africa

Although Kenya and South Africa have similar licensing policies and regulations, some differences exist in implementing and enforcing these policies. For instance, in Kenya, the licensing process is decentralized, with businesses required to obtain permits from the county government where they operate. In contrast, in South Africa, companies obtain permits from the municipality where they are located. Additionally, in Kenya, there are separate regulatory bodies for each industry, while in South Africa, the Department of Trade and Industry is

responsible for all licensing policies and regulations. In terms of compliance and enforcement, both Kenya and South Africa have well-established regulatory frameworks that promote compliance and accountability. However, there have been cases of non-compliance, especially in the construction industry, where unlicensed contractors and builders undertake construction work. To promote compliance and accountability, both countries have implemented penalties and fines for non-compliance, including revocation of licenses and closure of businesses.

In addition to the licensing policies and regulations discussed above, other aspects of licensing are essential to consider when analyzing the licensing procedures and rules in Kenya and South Africa. These include:

- Costs: Obtaining a license is critical in promoting compliance and accountability. In Kenya and South Africa, the cost of obtaining licenses varies depending on the license type, the industry, and the business size. High licensing fees may discourage small businesses and individuals from obtaining licenses, leading to non-compliance.
- Accessibility: Accessibility of licensing services is also essential to licensing policies and regulations. In Kenya and South Africa, licensing services are primarily provided by government agencies, and the licensing process may involve lengthy procedures and bureaucratic processes. This may discourage individuals and small businesses from obtaining licenses.
- Digitalization: The use of digital technology has the potential to enhance the licensing process, making it more efficient and accessible. In Kenya and South Africa, ongoing efforts are to digitalize licensing services, including online platforms, enabling businesses and individuals to apply for licenses and permits.
- Transparency: Transparency in the licensing process is critical in promoting compliance and accountability. In Kenya and South Africa, corruption and nepotism in licensing have led to unfair treatment and discrimination. Transparency in the licensing process can help prevent such cases and promote fairness and equity.

Another critical aspect of licensing policies and regulations in Kenya and South Africa is the role of licensing in promoting economic growth and development. Licensing procedures and rules are crucial in facilitating business activities and promoting entrepreneurship, essentially economic growth and development drivers.

In conclusion, licensing policies and regulations are critical in promoting compliance, accountability, and effective service delivery in any community. In Kenya and South Africa, well-established regulatory frameworks govern licensing policies and regulations. However, there is a need to address some of the challenges facing the licensing process, including costs, accessibility, digitalization, and transparency, to enhance compliance and accountability.

5.7 Regulation Laws for Community Networks in Kenya and Uganda

In Kenya, the Community Networks Regulations 2020 were issued by the Communications Authority of Kenya (CAK). The regulations aim to provide a legal framework for the licensing and regulating community networks in Kenya. In Uganda, the guidelines for licensing and regulating community networks were issued by the Uganda Communications Commission (UCC) in 2018. The guidelines require all community networks to be licensed and regulated by the UCC. Some of the critical provisions of the regulations include:

- **Licensing:** In Kenya and Uganda, community networks must obtain a license from the relevant regulatory authority to operate legally. The licensing process is designed to ensure that community networks meet specific standards, including those related to the quality of service, interference management, and reporting requirements. The licensing process also helps protect users' rights by ensuring that community networks adhere to specific guidelines and regulations. The permit is usually renewable after a certain period, three years specifically and five years in Uganda.
- **Spectrum management:** Spectrum management is a crucial aspect of community network regulation as it relates to allocating and managing radio frequencies used by community networks. The Community Networks Regulations in Kenya provide for administering and managing spectrum for community networks. The regulations require the Communications Authority of Kenya to allocate spectrum to community networks through the National Frequency Allocation Plan. In Uganda, community networks must use licensed frequencies and obtain approval from the Uganda Communications Commission (UCC) for any changes to their network infrastructure. These regulations aim to ensure that community networks do not cause interference with other licensed users of the spectrum.
- **Interference management:** Interference management is also crucial to community network regulation. It refers to the need for community networks to ensure that their operations do not interfere with other licensed users of the spectrum. This is important

because interference can cause problems for other users, including commercial telecommunications providers. Both the Community Networks Regulations in Kenya and the guidelines in Uganda require community networks to manage interference and ensure that their operations do not cause interference with other licensed users of the spectrum.

- **Quality of service:** The quality of service provided by community networks is also an important consideration. Community networks must provide a certain quality of service to their users, as the regulatory authority specifies. It specifies the quality-of-service requirements that community networks must meet. This is important because it ensures that users have access to a certain level of service. It also helps to promote the growth of community networks by providing a quality benchmark for the regulations in Kenya and Uganda.
- **Reporting requirements:** Reporting requirements are essential to community network regulation. Community networks must submit regular reports to the relevant regulatory authority, including information on their operations and financial performance. This information is used by the regulatory authority to monitor the performance of community networks and ensure that they are complying with the relevant regulations and guidelines. In Kenya and Uganda, community networks must submit regular reports to the regulatory authority, which helps ensure transparency and accountability.

5.8 The Different License Types and Exemptions Around the World

Community wireless networks (CWNs) refer to a wireless network set up and managed by community members. These networks provide internet access to individuals who might not have access to it otherwise. However, setting up and operating a CWN often requires licensed frequencies, which may be subject to various licensing requirements and exemptions depending on the jurisdiction [38]. This part of the chapter will discuss the different license types and exemptions worldwide that apply to community wireless networks.

5.8.1 Licensed vs. Unlicensed Spectrum

Wireless communication can take place in either licensed or unlicensed spectrum. Licensed spectrum refers to frequencies the government allocates to specific entities for exclusive use. These frequencies are typically auctioned off to the highest bidder, and the licensee is responsible for managing the spectrum and ensuring that they comply with any licensing requirements. In contrast, unlicensed spectrum refers to frequencies available for anyone

without a license [38]. The most commonly used unlicensed frequencies are the 2.4 GHz and 5 GHz bands used by WIFI networks.

5.8.2 License-Exempt Spectrum

Some jurisdictions allow the use of specific frequencies without needing a license. These are often referred to as license-exempt frequencies. The most commonly used license-exempt frequencies are WIFI networks, 2.4 GHz, and 5 GHz bands.

However, some jurisdictions may also allow using other frequencies on a license-exempt basis. For example, in the United States, the Federal Communications Commission (FCC) will enable frequencies in the 900 MHz, 2.4 GHz, and 5.8 GHz bands without a license for certain types of devices, including certain types of wireless routers [38].

5.8.3 Community Broadband Licenses

In some jurisdictions, community wireless networks can obtain a community broadband license to use specific frequencies for wireless communication. These licenses are typically issued by the government and are often subject to various requirements, such as power limits and interference restrictions.

For example, in the United Kingdom, community broadband licenses are issued by the Office of Communications, allowing communities to use frequencies in the 5 GHz bands for wireless communication. However, these licenses are subject to power limits and must be used in a way that does not cause interference to other users.

5.8.4 White Space Devices

White space devices are wireless devices operating in unused or unassigned frequencies in the television broadcast spectrum. These frequencies are typically in the range of 470-698 MHz and are subject to various regulations. In some jurisdictions, community wireless networks can use white space devices to provide internet access. For example, in the United States, the FCC allows using white space devices for unlicensed wireless communication, subject to various requirements [38].

5.8.5 Amateur Radio Licenses

Governments issue amateur radio licenses to individuals who want to operate amateur radio equipment. These licenses allow individuals to communicate using frequencies reserved for amateur radio use. While not specifically designed for community wireless networks,

amateur radio licenses can be used by community groups to set up wireless networks that operate on amateur radio frequencies.

For example, in the United States, the FCC issues amateur radio licenses that allow individuals to communicate on frequencies in the VHF and UHF bands. While these licenses require passing an exam and meeting specific requirements, they can be cost-effective for community groups to set up wireless networks without purchasing expensive permits.

5.8.6 Spectrum Sharing

In some jurisdictions, regulators have implemented spectrum-sharing frameworks that allow different entities to share the same frequencies for wireless communication. This can help facilitate wireless communication for community networks by reducing the barriers to entry and allowing multiple entities to use the same frequencies. For example, in the United States, the FCC has implemented various spectrum-sharing frameworks enabling numerous entities to share the same frequencies in the 3.5 GHz and 5.9 GHz bands. These frameworks include the Citizens Broadband Radio Service (CBRS) and Dedicated Short-Range Communications (DSRC) [38].

5.8.7 Open Spectrum

Another concept related to community wireless networks is the open spectrum. Open spectrum refers to a wireless communication environment where all frequencies are available for use by anyone without the need for a license. Proponents of open range argue that it can lead to more innovation and competition in the wireless communication industry.

While no jurisdictions have implemented fully open spectrum, some have implemented policies that allow for limited available spectrum use. For example, the United States has implemented a policy allowing TV white spaces for unlicensed wireless communication, which can be considered a narrow open spectrum [39].

5.8.8 Digital Divide Exemptions

Digital divide exemptions refer to policies that exempt certain entities, such as community wireless networks, from licensing requirements to address the digital divide. The digital divide refers to the gap between those with access to digital technologies and those without access. Digital divide exemptions aim to address this gap by allowing community wireless networks to provide internet access to underserved communities.

For example, in the United States, the FCC has implemented the EBS (Educational Broadband Service) program, which allows educational institutions, including community organizations, to apply for licenses to use spectrum in the 2.5 GHz band for wireless communication. These licenses are subject to specific requirements, such as providing educational programming to the community.

5.9 Conclusion

In summary, open spectrum and digital divide exemptions are additional concepts that can facilitate wireless communication for community wireless networks. While no jurisdictions have implemented fully available spectrum, limited forms of the open spectrum and digital divide exemptions have been implemented in some jurisdictions to address the digital divide and promote innovation in wireless communication. In conclusion, various licensing types and exemptions worldwide apply to community wireless networks. These include licensed spectrum, unlicensed spectrum, license-exempt spectrum, community broadband licenses, white space devices, amateur radio licenses, and spectrum-sharing frameworks. Community wireless networks can choose the licensing type or exemption that best suits their needs and complies with local regulations.

CHAPTER 6: CONCLUSION

In conclusion, the policy, regulation, and community wireless are all interconnected and play a crucial role in ensuring that wireless communication is accessible, affordable, and secure for everyone. Wireless technology has revolutionized communication, becoming an essential aspect of modern life. However, the benefits of wireless technology cannot be fully realized without adequate policies and regulations that ensure fair and equitable access for all.

Community wireless networks have emerged as a popular alternative to traditional commercial networks. Community members often develop and manage these networks to provide affordable and reliable wireless connectivity in underserved areas. However, these networks face regulatory challenges and are often subject to restrictive policies that limit their growth and potential impact. To address these challenges, policymakers and regulators must develop policies that support community wireless networks and promote competition in the wireless market. This can be achieved by removing barriers to entry for new market players, encouraging spectrum sharing, and promoting the development of open standards for wireless technology.

Cybersecurity threats such as hacking and data breaches are a significant concern in wireless networks, and policies and regulations must be in place to protect user data and information. Moreover, policymakers and regulators must also prioritize the security and privacy of wireless networks. In conclusion, the success of wireless technology depends on the effective integration of policy, regulation, and community initiatives. By promoting fair and equitable access, encouraging competition, and prioritizing security, policymakers and regulators can create an environment that fosters innovation, promotes social equity, and enables the full potential of wireless technology to be realized.

References

[1] Canada's Public Policy Forum, "Northern Connections Broadband and Canada's Digital Divide," Public Policy Forum, Ottawa, 2014.

[2] Center for Neighborhood Technology, "Community wireless networks," Center for Neighborhood Technology, Illinois, 2006.

[3] "Canada.ca," 06 2007. [Online]. Available: https://ised-isde.canada.ca/site/spectrum-management-telecommunications/en/official-publications/policies/spectrum-utilization-policies-sp/spfc-spectrum-policy-framework-canada. [Accessed 06 02 2023].

[4] [Online]. Available: http://transmissionproject.org/projects/champaign-urbana-community-wireless-network-cuwin.

[5] S. Yucel, Smart Community Wireless Platforms: Costs, Benefits, Drawbacks, Risks, Recent Trends in Computational Science and Engineering, IntechOpen, 2018.

[6] [Online]. Available: https://en.wikipedia.org/wiki/%C3%8Ele_Sans_Fil.

[7] [Online]. Available: http://wirelesstoronto.ca/.

[8] A. Powell, "Community Wireless Infrastructure Research Project (CWIRP)," Concordia University, Concordia, 2008.

[9] D. Bean, "Commotion Wireless: Free and Open Way to Network," 2013.

[10] D. J. Wesley Chai, "TechTarget," The jacobs group, [Online]. Available: https://www.techtarget.com/searchnetworking/definition/wireless-mesh-network. [Accessed 03 02 2023].

[11] "CenturyLink," [Online]. Available: https://www.centurylink.com/home/help/internet/wireless/which-frequency-should-you-use.html#:~:text=penetrating%20solid%20objects-,2.4%20GHz%20vs.,use%20your%20WiFi%20connection%20most.. [Accessed 05 02 2023].

[12] Bruno Ramos, Luca Belli, The Community Network Manual: How to Build the internet yourself, Paris: FGV Diereito Rio, 2018.

[13] Charlene, FS community, 13 07 2021. [Online]. Available: https://community.fs.com/blog/wireless-access-point-vs-router-what-are-the-differences.html. [Accessed 05 02 2023].

[14] CONTRATSCOUNSEL, [Online]. Available: https://www.contractscounsel.com/t/us/acceptable-use-policy.

[15] P. Kirvan, "Authentication and access control," TechTarget, [Online]. Available: Authentication and access control. [Accessed 06 02 2023].

[16] "BELL BUSINESS INTERNET AND VALUE ADDED SERVICES-ACCEPTABLE USE POLICY," [Online]. Available: https://www.bell.ca/styles/common/en/all_regions/pdfs/sme/BELL_BUSINESS_INTERNET_AND_VALUE_ADDED_SERVICES_Acceptable_Use_Policy.pdf. [Accessed 09 02 2023].

[17] "ROGERS TERMS OF SERVICE AND ACCEPTABLE USE POLICY," ROGERS, [Online]. Available: https://www.rogers.com/cmsbusiness/download/hostedipvoice/Hosted_IP_Voice_Terms_of_Service_5.0_en.pdf. [Accessed 09 02 2023].

[18] "TELUS Business," TELUS, [Online]. Available: https://www.telus.com/en/ab/business/support/article/acceptable-use-policy?INTCMP=VAN_aup. [Accessed 09 02 2023].

[19] Government of Canada, "Canada.ca," [Online]. Available: https://crtc.gc.ca/eng/acrtc/org.htm. [Accessed 22 02 2023].

[20] H. K. Bhabha, Spectral Sovereignty, Vernacular Cosmopolitans, and Cosmopolitan Memories, Bruce Robbins, 2017.

[21] C. Gomez, "TV White Spaces – Managing the spaces or better managing inefficiencies?," in *Radiocommunication Bureau, ITU*, Poland, 2013.

[22] M. Mahloo, "Cost Modeling of Backhaul for Mobile Networks," IEEE, Sweden, 2014.

[23] M. C. W. S. Ye Hu, "Joint Access and Backhaul Resource Management in Satellite-Drone Networks: A Competitive Market Approach," IEEE, 2019.

[24] Government of Canada, "Canada.ca," Infrastructure Canada, [Online]. Available: https://www.canada.ca/en/office-infrastructure/news/2018/05/high-speed-internet-and-4g-wireless-in-every-northwest-territories-community.html. [Accessed 22 02 2023].

[25] T. Ahmmed, "The Digital Divide in Canada and the Role of LEO Satellites in Bridging the Gap," IEEE Communications Magazine, Ottawa.

[26] S. Sasmita Mohanty, "CE-Driven Trends in Global Communications: Strategic sectors for economic growth and development," *IEEE Consumer Electronics Magazine,* vol. 6, no. 1, pp. 61-65, 2016.

[27] R. Mijumbi, "Network Function Virtualization: State-of-the-art and Research Challenges," IEEE Communications Surveys and Tutorials.

[28] M. A. Rob McMahon, "Voices from Northern Canada: Integrating stakeholder expectations in telecommunications policy for rural, remote and Northern regions," *Journal of Rural Studies,* vol. 46, no. 9, 2022.

[29] D. Johnson, "Performance of a Rural Wireless PTMP Network with Integrated Data," University of Saskatchewan, Saskatchewan, 2022.

[30] G. Chowdhury, "Promoting access to indigenous information in Africa: Challenges and requirements," *SAGE,* 2021.

[31] Government of Canada, "Policy on Acceptable Network and Device Use," Canada.ca, 31 03 2020. [Online]. Available: https://www.tbs-sct.canada.ca/pol/doc-eng.aspx?id=27122. [Accessed 15 02 2023].

[32] Office of the Auditor General of Canada, "Connectivity in Rural and Remote Areas," [Online]. Available: https://www.oag-bvg.gc.ca/internet/English/att__e_43221.html.

[33] "Research on Telecommunications Services in Northern Canada," Canadian Radio-television and Telecommunications Commission, Gatineau, Quebec, 2020.

[34] M. Ding, "Performance Impact of LoS and NLoS Transmissions in Dense Cellular Networks," IEEE, 2015.

[35] R. Schneir, "A cost study of fixed broadband access networks for rural areas," *Telecommunications Policy,* vol. 40, 2016.

[36] M. K. Josephine Miliza, "Community Networks Policy Brief," Kenya ICT Action Network (KICTANet), 2020.

[37] S. P. C. Rey-Moreno, "Advancing Rural Connectivity in South Africa through Policy and Regulation: A Case for Community Networks," Kampala, Uganda, 2020.

[38] C. Stevenson, "The First Cognitive Radio Wireless Regional Area Network Standard," *Communications Magazine,* vol. 47, no. 1, pp. 130-138, 2009.

[39] M. Matinmikko, "Spectrum sharing using licensed shared access: the concept and its workflow for LTE-advanced networks," *IEEE Wireless Communications,* vol. 21, no. 2, pp. 72-79, 2014.