Community Network Roadmap

A Guide for Building and Maintaining Digital Connectivity for Your Community

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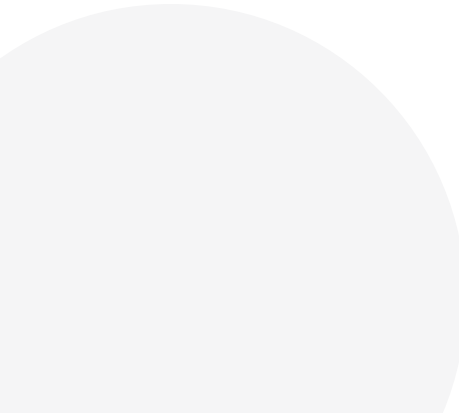
HOW TO READ THIS ROADMAP

You can either read the Roadmap from beginning to end or choose a topic and explore.

The Roadmap is organized by our sense of how a community network gets created, step–by–step, but each topic area can also be expored separately depending on your needs.

The information in the Road Map is organized in two ways: Building the network, and Maintaining the network.
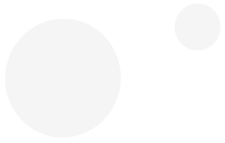
The **Build** sections focus on the kinds of information and tasks particularly relevant to starting your network. There are many things to consider in the planning and building of a first network, and these sections are designed to help you think your way into developing and executing a successful community network plan.

The **Maintain** sections focus on longer term considerations. Once the network is up and running, there are different kinds of problems that can arise and need to be considered and planned for – tasks and matters aimed at keeping a community network operation sustainable and stable over time.

Both ways of thinking about a community network are important. But of course, one comes before the other. Use the guide in a way that is relevant to your situation.

Note: Click on the links in the document to view them, as copying and pasting may introduce some errors.

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01

INTRODUCTION

Community networks (CNs) provide access to **affordable, reliable digital network services** that are designed and operated by the local community. Community networks emphasize technical solutions for specific local needs, **community member control** over decision making, community participation and skills training.

Communities all over the world are designing, building and operating their own digital communications networks. Community Networks can be found on every continent, some as small as a few households, others like the *Guifi.net in the Catalan region of Spain*, with tens of thousands of network members.

Community networks are an effective way to get digital networking and the Internet into communities that otherwise would not have access.

SCN volunteers working on Skyway Library cell site install in 2021

Tropical Regions

Northern Communities

Urban Centers

The Prairies

Community Networks thrive in every kind of landscape; their low cost and reliability are common reasons why people appreciate them.

Rural Areas

Mountainous Regions

Community networks present numerous benefits alongside a set of challenges.

Advantages: The advantages of community networks include affordability, reliability of services, capacity building (technical skills training), meeting neighbours and building relationships, community independence, shared costs, collective ownership, local content, digital inclusion, community solidarity, data privacy and security, economic investment that stays in the community, and having a digital network that is responsive to local needs.

Challenges: Community networks require time and effort on the part of network members—solving technical problems, decision-making, financial management, network planning and growth, and sustainability planning all demand attention from community members. Sharing responsibilities is a key path towards long-term sustainability.

Digital networks might be inaccessible for many reasons: The infrastructure may not exist, or if it does, it is unreliable and/or unaffordable; commercial providers and policy-makers may not prioritize local community needs. Community networks can address all of these problems.
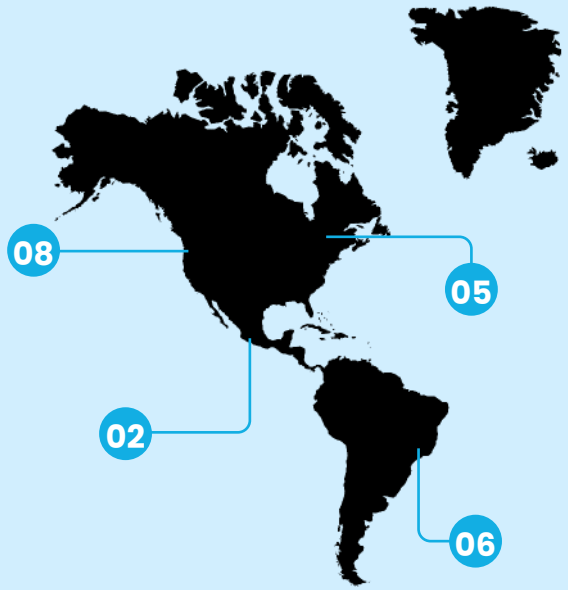
Examples of Living Community Networks

Community networks thrive globally, with numerous flourishing examples. Tapping into the experiences of other community network organizations can provide valuable insights for planning and running your own network. With hundreds of successful community networks out there, a wealth of knowledge awaits.

These are just a few examples of the many living community networks around the world. If you would like to add your network to a repository of community networks, please fill out this form and we'll get in touch with you! *https://bit.ly/globalcn*
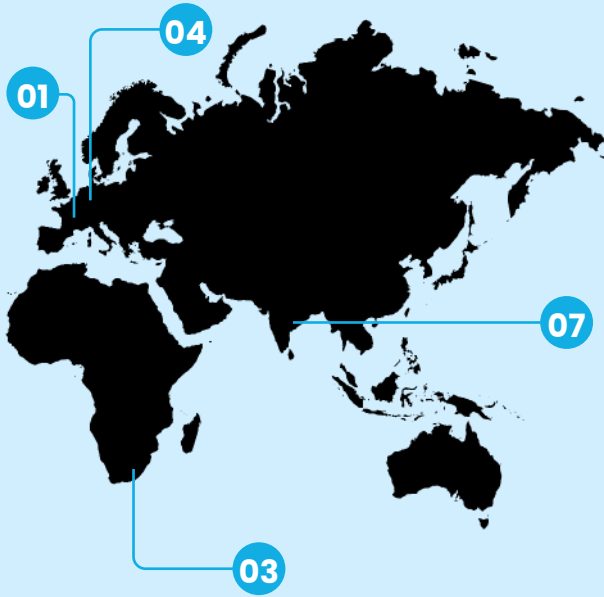
01. Guifi.Net
https://guifi.net/en

05. New York City Mesh
https://www.nycmesh.net

02. Rhizomatica
https://www.rhizomatica.org

06. AlterMundi.Net
https://altermundi.net/

03. Zenzelini.Net
https://zenzeleni.net

07. Wireless for Communities
https://wforc.in

04. Freifunk.Net
https://freifunk.net

08. Seattle Community Network
https://seattlecommunitynetwork.org

02

TEAM BUILDING

Community networks are as much about people as they are about technology. It is people who will decide what technologies to use, how to deploy them in the community, how to maintain network operations and how to grow the community network to serve local needs.

Community networks are often started by a small handful of interested and dedicated community members, sometimes as small as two to five people. A core element is a shared sense of determination to solve their local connectivity problems.

Community Outreach and Sustained Engagement

Consider the core skills and knowledge required for creating and sustaining a community network: leadership and team–building, IT and network administration (i.e. managing computers and routers), community outreach, training, conducting

workshops and financial management. Schools, local businesses, community centers, health facilities, advocacy organizations can be **important allies** when developing a community network. Reach out to stakeholders in the community who can share some of these skills, either by participating in network planning or offering workshops.

Leadership & Organizing

IT & Network Administration

Team Building

Core skills and Knowledge

Teaching & Training

Financial Management

Community Outreach & Marketing
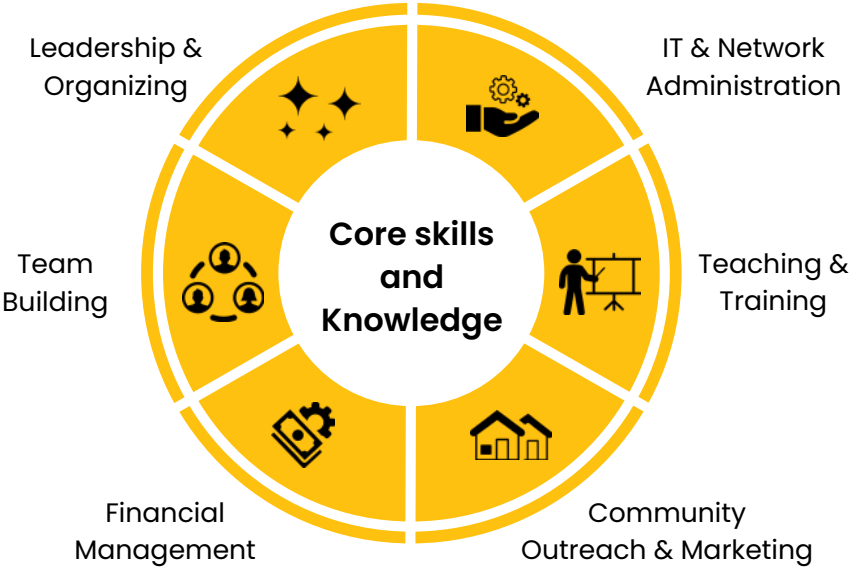
Important Allies

Local Schools

Advocacy Organizations

Health Facilities

Community Centers

Local Businesses

IT & Network Administration (Online Learning Materials)

Technical networking skills can be more specialized. There are people (and learning resources) available on the Internet specializing in community network building.

Below is a list of resources and organizations. Training interested community members and finding community members already familiar with digital network technologies are both excellent strategies.

01. **Community Network Readiness Assessment Course (Internet Society)**
https://www.internetsociety.org/learning/community-network-readiness/

02. **Community Networks Training Webinar (Internet Society)**
https://www.internetsociety.org/events/indigenous-connectivity-summit/2021/trainings/community-networks-webinar/

03. **Community Networks Learning Repository**
https://cnlearning.apc.org

Building long–term community resilience requires capacity building.

To help community members get the necessary skills required to keep the network running, cosider facilitating **regular workshops in all areas of network operations**—community–building and outreach, network administration, governance and leadership, financial management, and technical troubleshooting.

Attend community events, set up an information table where you can demonstrate equipment and answer questions, and/or host a community BBQ. The network's survival over the long term will depend in part on maintaining, renewing and expanding interest and support from community members. A **community presence** can also help to grow the network. Teamwork not only strengthens the network but also creates a cooperative vibe in the community, promoting a shared goal of local growth and staying connected.

Seattle-based digital stewards training program by the Black Brilliance Research Project, Spring 2023

Identify community needs

When building support for a community network, understanding the different needs of different community members is essential.

Where is coverage needed?

What are the barriers to access?

Cost?

Reliable Service?

Access to a computer or smartphone?

Digital literacy skills?

Content Language(s)?

Understanding the full range of community needs helps with designing a community network that the community will find helpful and support.

Community needs are never static

Accessibility will likely change over time (for example, changing Internet service prices or changing locations of where ISPs have deployed transmission towers, cable or fiber), as will people's expectations of what kind of service they need (e.g. speeds).

The more that network design and operation can reflect real community needs, the more likely the network will be supported by diverse community members.

Population demographics in a region may vary. It is essential to **maintain procedures for integrating and on-boarding new people**, as well as maintaining or expanding your community-building activities. These considerations can also help to expand your physical network.

Leadership and Organizing

As community networks are locally owned, you will have many decisions to make: Where to build the network, what equipment to use, how to manage costs, where and when to organize community events, how to sort out problems, what kinds of workshops to present and how often, policy decisions, etc. The community network will require a system of decision–making (or governance) that is transparent, inclusive and accountable to the broader community.

Accountability is crucial: Who will ensure tasks get done and be responsible for how the network is created, its operations and impacts? The governance structures you implement will also depend on how many people are involved. Find a decision making structure that makes sense for the group you are working with. The network will require decision–making in many different areas. If it is a small group, one organizing committee might make sense. But with a larger group, consider setting up a committee structure to encourage members with particular strengths into relevant conversations.

Key areas of decision–making include community outreach/support, technical design & build, capacity building/workshops, troubleshooting & network maintenance, finances & legal considerations.

Even when your network has reached a level of organizational maturity, how easy is it for new people to come in and have their voices heard, for them to participate in decision making and feel that they have a meaningful impact on the community? This can be key to **keeping new people engaged** after the initial spark of inspiration which causes them to join or come to their first meeting.

What happens when very active users, volunteers, employees, or contributors leave the network or move away? Are there processes in place to turn their **roles and responsibilities** over to new people, as well as keeping documentation to help with **knowledge retention** and transfer? Are there processes for roles to be redefined or recognized and reallocated? Are people elected into leadership roles via **democratic processes** that feel fair (however formal or informal)?

Sometimes forcing turnover (via term limits etc) can be a good idea for establishing these turnover processes concretely and not just in the abstract, even if it seems unnecessary at any given moment.

Organizational Structures

Leadership roles can be helpful. Consider establishing leadership roles for community outreach & new member recruitment, volunteer coordinating, technical design and build, capacity building/workshops, finances & legal considerations. Leadership roles can be linked to committees to create small teams of **problem solvers** in specific areas.

Weekly helpdesk at Filipino Community Center

Consider **succession strategies** for key roles in the network. How will wisdom and knowledge be shared and passed on? How will key roles be replaced if someone moves or decides to step down? Consider an under–study or assistant framework where no one is working alone, and someone is always in a learning position, i.e. **ongoing capacity building with every position.**

Regular governance meetings are important for community and team building as well as infra-structure upkeep. They are a chance for network members to air complaints, make suggestions, and maintain accountability and a steady pace of progress. They are an important way to ensure transparency and fairness in decision–making. They are **a strategic way to prevent problems**, to address problems in a timely way, and to take advantage of opportunities. Regular governance meetings, even when the network is not being actively set up or growing, help stabilize network operations over the long term.

Equity, Diversity and Inclusion

Consider who the decision–makers are and questions of **equity, diversity and inclusion.** Who could be invited into the decision–making process that might otherwise be excluded or forgotten?

Are the decision–makers representative of and respected/loved by the community? You can think of representation in terms of gender, class, ethnicity, socioeconomic background, sexuality, disabilities, etc. Still, of course, humans are more than demographics; these are certainly not the only important features.

Diversity is strength—the more allies you have in the community who are willing to sit at the same table and work together, the better the network's chances for long–term sustainability.

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Policies and Regulations

Identify the policies and regulations that affect the network—municipal, regional, and national. What are the **telecommunications rules and regulations**? In Canada, the Canadian Radio–Telecommunications Commission (CRTC) sets digital network rules and regulations. In the United States it is the Federal Communications Commission (FCC). Most countries have a regulatory agency that sets communications policies. Find out what rules and regulations apply to community networks and internet service providers.

What kind of an organization will run the network? Will it be incorporated as a not–for–profit? Small business? Community organization? What rules and regulations, filing requirements, taxation, and insurance will be required?

Maintain

Once you know what rules and policies apply to your community network, you may find that some work against the network's interests. Consider trying to have the rules changed. Are there policies that might help it thrive? Where it makes sense, you can build relationships with elected leaders and tele-communications officials, and advocate for policies that benefit community networks. You can find a global wiki and community of support at *https://policy.communitynetworks.group*.

Establishing Community Support

Inclusivity and diversity are essential to the long-term health of the network.

- Build relationships with community members.

- Make it easy for people to get involved.

- Create procedures for bringing people into the organization; consider pairing new members with a more experienced community member (i.e. a network mentor) to help them learn about the organization and how it works.

- Be attentive to how different individuals want to participate.

- Create opportunities for skills learning through hands–on direct experience and/or workshops.

Establishing relationships with other community networks may be an effective way to get help when you need it. Reach out to one or more of the networks listed in this document or any community networks nearby. Introduce yourself and your project. Share experiences, wisdom and resources as appropriate.

Keeping track of successes and achievements is vital for sharing the network's story with other community members, potential funders, policy–makers, and so on.

Reach out and check in periodically with your partner organizations or network members, e.g. once a month, to make sure their needs are met.

Keep a record or log book of accomplishments.

It is also important to recognize the contributions of individual community members.

Use celebrations to acknowledge and reward hard work and to invite new community members into the network.

Keep complete documentation of all eployed equipment and infrastructure (such as login passwords, photos, and what is plugged into what). Define and use access control practices to keep this info out of the wrong hands, but make sure it's always available to the right people who are responsible for maintenance.

Online Community

Establish social media platforms or channels where community network participants can share information, concerns, experiences, ideas, technical information and solutions to problems. Examples include WhatsApp, Discord, slack, etc.

Physical Events

The sense of camaraderie among network participants should be more than just work oriented. **Have fun!** Hold regular social gatherings—BBQs, shared meals, outdoor/indoor games, clothing swaps. Informal gatherings like this can be invaluable ways for people to share information, network, meet others in the community, and build relationships.

SCN Social Picnic 2021

Consider annual or semi–annual events inviting the broader community into the community network conversation. Ask how well the network is serving needs: where is it succeeding, where is it falling short, who needs access but does not have it, and what are the issues and concerns being faced by community members?

Consider creating ongoing, accessible opportunities for regular feedback. Incorporate feedback into decision–making processes.

SCN Hack Night at the Filipino Community Center

Governance and Finances

Community networks require money to
build and maintain.

Consider how money will be handled for the network organization: Who will be entrusted to manage finances, i.e. a treasurer? Will you open a bank account for the network with multiple signing officers? How will you raise money? (e.g. grants, user fees, membership dues, fundraising activities like Bingos, bottle drives, bake sales, etc.). If there are user fees, who will collect them? What if members are late or don't pay?
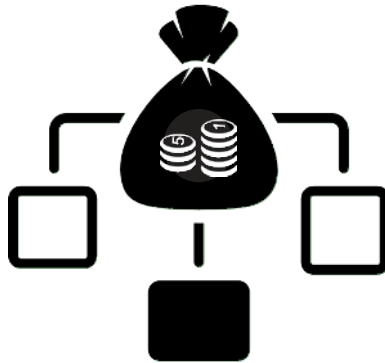
Explore what kind of organization will run the network procedures in your region. Reach out to other, similar organizations or pro–bono legal services for guidance.

Longer–term financial planning for community networks requires planning for unexpected technical failure and replacing equipment, technological upgrades, tools and supplies, crowd–sourced funding strategies, grant writing strategies, and other sources of revenue generation.

Consider creating a committee or group to think about longer–term network goals and visioning. Create space and time outside of addressing day–to–day issues for long term planning.

The people doing long term visioning should be well informed of day–to–day network operations to ensure continuity and strategic planning.

03

PLANNING A NETWORK

Community networks can be created with different technologies, but they all share the key goal of carrying data from one location to another, whether through wired cables or wireless signals transmitted through the air. It might be from household to household (as in a mesh network), or it might be from a more centralized transmitter to multiple households and users (as with an Access Point).

The key steps are:

01. Obtaining an Internet connection or "backhaul" if desired

02. Sharing this signal to one or more locations in the community.

SCN volunteers installing LTE network at Franklin High School in Seattle, 2021

Glossary of Technical Terms

Backhaul: This will be the internet connection coming into your community and shared via your network. There may be multiple sources or locations for backhaul in your network. Each backhaul connection may look different– it could be a fiber–optic cable coming into your building, a wireless point–to–point link on your roof (described below), or an ethernet port on your Internet Service Provider (ISP)'s router.

Access networks: This is the part of the network that connects your end users to their backhaul (source of internet). They can be wireless (e.g. WiFi or cellular) or wired (e.g. cable or fiber to the home).

Access Points (APs): These are special nodes that share network access with many users from a single point, creating "access networks." Cellular towers and WiFi routers that a smartphone uses to connect to the internet are all different types of "access points."

Captive Portal: Sometimes called a Splash Page, a captive portal directs any user of a particular network to one particular webpage. The user is required to view and interact with this webpage before they can access the network.

Data Centre: Organizations who provide centralized data storage services for one interdependence,

autonomous management, and growth.

Middle Mile Network: Middle Mile Network describes Internet infrastructure that links together "last mile" (i.e., local) networks to the wider Internet through regional networks and service providers.

Point–to–point (PtP) link: A connection (usually wireless) between just two devices (point A to point B). These links tend to use very tightly focused directional antennas, such as parabolic dishes, that have to be aimed accurately at each other.

Point–to–multipoint (PtMP) network: A network (typically wireless) connecting one point with several others (for example, an AP and multiple end users). These antennas tend to look very different, for example like flat panels or wider horns, so that their signal can be spread across a wider angle in space to communicate with multiple devices at once.

Virtual Network: Virtual networks are networks created with software and hardware to emulate physical networks by linking together a specific group of devices and users, for example a large company who creates a virtual private network (VPN) to create secure and efficient data flow among its employees.

References: Lesson 6–Designing a Network–Aug 1:
https://bit.ly/ds-lesson-designing-wireless

An important consideration for community net-works is the question of **tiered access.** Will every-one in the community have the same access to the network, or will the network offer tiered services; that is, different services depending on the level of commitment or engagement. For example, a community network can offer limited free services for everyone in the community with certain restric-tions such as band width, time or usage, and unlim-ited services for network members who volunteer or pay fees, etc.

Technical Planning

Planning your network will require gathering infor-mation. Here is a list of questions to guide your planning:

01. Intranet v. Internet? If access to the Internet is an integral purpose of your network's opera-tion, where will you source backhaul?

02. What is the geographic territory that you want the network to reach? Where are the users, and what network speeds will they require for their everyday use?

03. Which radio technologies and radio frequen-cies to choose for your community network? WiFi, TV White Space, etc. This may depend on

local regulations and licensing available to you, as well as cost for equipment and operation, and complexity of the install (such as power requirements).

04. For wireless networks, you will likely need line–of–sight (LoS) between nodes if you are using high radio frequencies (upwards of 1GHz). If so, what topographical features must be taken into consideration in planning node locations?

05. Who do you need permissions from for access to backhaul sites or high points? For mounting equipment on these structures or land?

06. Do you have the required technical know–how and/or tools to build and install network equipment? Who in the community has the technical know–how and any required licenses (such as for electrical work)? Who outside of the community can you ask for help? What training opportunities are available?

07. Open source or Paid services? While popular among CNs for their DIY spirit and low cost, open source ecosystems are ever-changing. If you anticipate needing lots of outside technical support, low-cost commercial options may better suit your needs. It will help to stay up-to-date about both types of options.

How Community Networks Work (Technical Primer)

You can think of wired networks as hoses carrying water, and wireless networks as sprinklers or spigots for the water. Wired networks such as fiber–optic, cable, or ethernet will often be higher performance (faster speeds) than wireless networks, and (depending on how rugged the implementation, for example whether conduit is used for wires) will often be more resilient to the elements and easier to maintain. However, wireless networks can be much cheaper when starting out, because you need less equipment and physical material to cover a large area with network access. Low–end wireless equipment will typically need to be upgraded sooner and go out of date faster due to the changing expectations of users, their devices, and web technology.
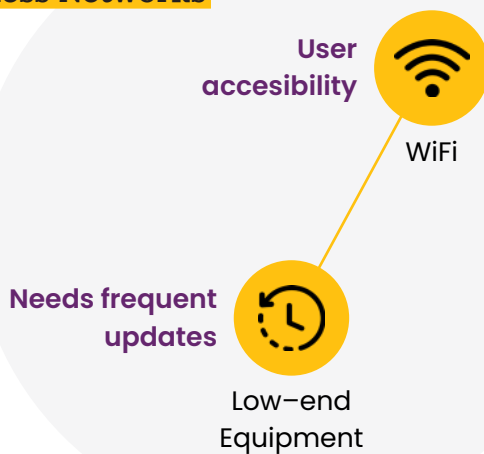
Wireless networks (such as WiFi) are also how your users will probably ultimately use the internet access, so they will be necessary in the end.

Wired Networks

More resilient

Fiber–optic

Cable

Higher performance

Ethernet
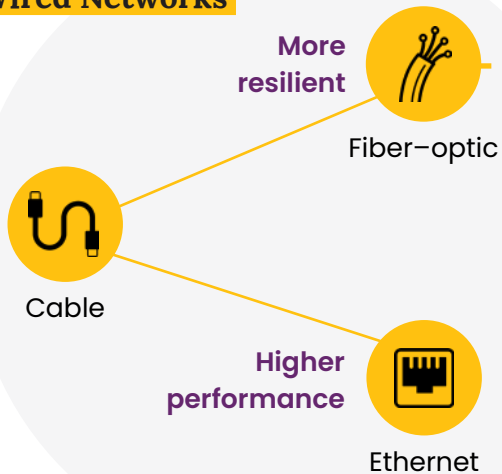
Ultimately connects to

Wireless Networks

User accesibility

WiFi

Needs frequent updates

Low–end Equipment

Network Relationships & Maintenance

Every piece of equipment you deploy, as well as the location you deploy it on (and the corresponding relationship and logistics that give you access to that location), will need to be maintained for the continued operation of the network.

Make sure you have good communicators on your team who are ready and willing to maintain and strengthen community relationships over time.

Your network will consist of one or more following components: a "core network," "backhaul links" for your nodes, and "access networks. All of these may incur operational costs and require maintenance."

```
┌──────────────┐     ┌──────────────┐     ┌──────────────────┐
│ Core Network │┄┄┄┄│Backhaul Links│┄┄┄┄│ Access Networks  │
└──────────────┘     └──────────────┘     └──────────────────┘
       └──────────────────────┬────────────────────┘
                    ┌──────────────────────┐
                    │  Operational Network  │
                    └──────────────────────┘
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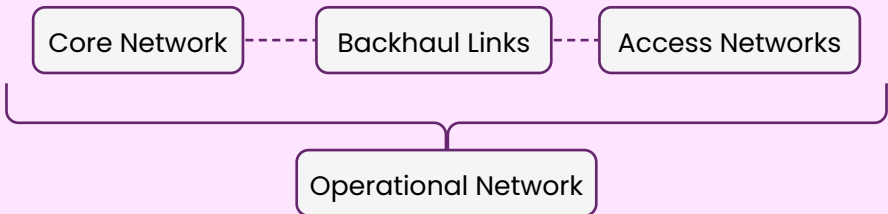
Backhaul links or "upstream" internet service are typically paid for on a recurring basis, unless you have an ongoing donation of a certain amount of bandwidth through an ISP, university, or other institution. **Look for support from regional middle mile service providers** who often operate as nonprofits for the benefit of research and education.

These agreements are easier to get if you have equipment located in a data center or **Internet eXchange Point** (IXP) that ISPs connect to.

If your backhaul is provided through a **wireless point–to–point (PtP) link**, you may need to rent or access donated roof space as well as electricity to support your equipment.

Your equipment may also need maintenance, for example if it gets damaged or knocked out of alignment by weather (frequent in some areas). Be sure to establish processes, human roles and responsibilities (including skills training if needed), and expectations for this maintenance.

Access network equipment such as WiFi routers will also need ongoing power, space and mounting locations/permissions, and maintenance. **Users will need support over time** with troubleshooting or updating their access networks, so think about how they will reach you and other network members (e.g. via phone number, email, WhatsApp, or other communication platforms). It may help to set up a "captive portal" (or splash/landing page) for public or guest access networks (often offered for non–members) that help spread information about your community network and limit "hogging" of network resources by non–members via time or bandwidth limits.

How will users communicate and get help if there is a network outage?

Set up protocols and signage (such as stickers on equipment or printed forms/signs) for how users will reach out for help, troubleshoot, and keep track of information such as their WiFi passwords and equipment locations. Manage their expectations for how they will be helped, by who, how quickly, and how independent they are expected to be. You will likely want to exchange contact info, and set up member **agreements and terms of service** for new users to sign Many networks also depend on automated recurring payments (often structured as suggested donations), and/or expectations for recurring participation or labor from their members as part of the membership model.

If you have a **mesh network**, new nodes' connectivity will come to depend on nodes and people that joined the network before them. The interconnectedness created by a mesh network structure can be a strength for community maintenance, as the nodes' physical interdependence can knit relationships together. However, the physical topology of a mesh network may be more fragile and require more frequent physical labor to keep up and repair. The maintenance of the firmware or software may

become a pain point, because "standard" commercial network equipment configurations and firmware often do not support mesh networking functions. Special and often open–source firmware may have to be "flashed" (i.e. uploaded manually onto devices). See our Resource Guide near the end of the Road Map for opensource network software suggestions.

Mesh Networks
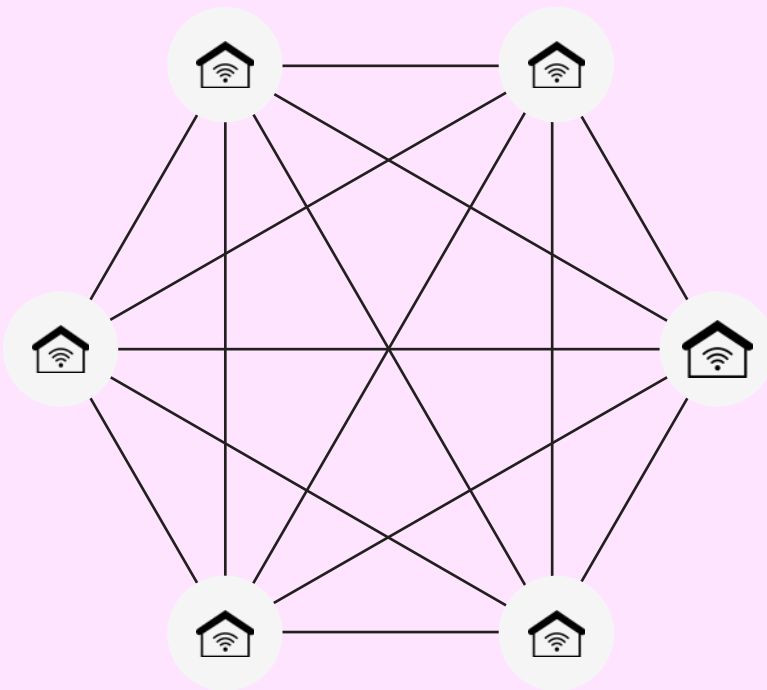
Example of full mesh network topology

Wireless Coverage Area Analysis

Designing and planning a network means thinking about both where network nodes should physically be installed to cover the intended user population, who owns the land, whose buildings are in strategic locations, how signals can be moved from one part of the community to other parts.

Wireless connections often rely on **line-of-sight (LoS)**, i.e. data can only be sent if the transmitter and receiver nodes can visibly see each other without obstructions between them. This means an understanding of regional topography is needed to design the network.

- Where are your backhaul connections physically available, and where are your intended users located?

- Where are the high points and low points in the community?

- How will you get signals to low-lying areas if needed?

- Are there trees, mountains or buildings between intended nodes that have to be worked around or added to the network?

Obstruction by
trees

Clear Line–of–
Sight (LoS)

Line of sight Image Refrence:
https://www.crowsnestbb.net/how-it-works.html
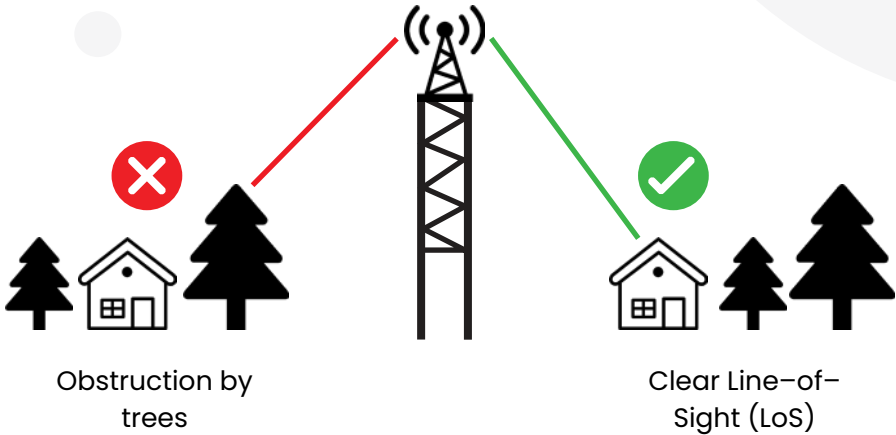
Try drawing a map of the region you are hoping to reach with the network, showing relative heights of features in the area. You can use free **topography data and mapping tools** such as Google Earth Pro to run a "viewshed analysis" to see what LoS looks like from any given point.

References:

- Lesson 6 – Designing a Network – Aug 1:
- *https://bit.ly/ds-lesson-designing-wireless*
- Inventory the Neighborhood: *https://commotionwireless.net/docs/cck/planning/inventory-the-neighborhood/*
- Google Earth Pro: *https://www.youtube.com/watch?v=ad7bMGPDwcw&list=PLZ1cQ-u1XTA7nkhdE5XfU-FLCEBfUbkt0x&index=6*

Strategic Planning

Network Expansion and User Base Planning
Sometimes it can be hard to predict who will be interested in joining, which can make coverage area planning hard. More community engagement and planning ahead can make this easier, but be ready to adapt the network to a changing user base. Ideally, when you plan your network you want take into account possible future users to make any expansion more efficient and easier.

- Do you have a good idea of where future users are located, i.e. community members who one day you may have to reach with the network?
- Do you have a **plan for growth**/expansion?

Supporting Network Reliability and Maintenance
Every link you establish (especially wireless) will need to be maintained by you or other members over time. Ensure that each new link or piece of equipment is explicitly "on someone's radar" with a plan for maintenance and monitoring, even if that person is just the DIY end-user themself.

- How will you or other community members be informed when a link fails or decreases in effec-tiveness, e.g., if wireless point–to–point antennas become misaligned due to strong winds? Do you have **backup communications channels**?

- Will you use software for automated **network monitoring or data collection**? Compatible software may depend on specific features of your network devices, e.g. their supported firmware (such as OpenWRT, compatible with **OpenWISP**) or monitoring protocols (such as **SNMP**).
- Are there high points that are very hard to access in your network design, for example mountain tops or telecommunications towers? Will you **need to hire** a certified tower climber to maintain this gear, or is there someone reliably available in your community who can do it?
- Will two people or organizations on either side of a link be able to **maintain good working relationships** and procedures over time so they can repair their link if it becomes disconnected (even several years after being installed)?
- Is there a plan for **replacing damaged gear**, e.g. after lightning strikes? How about gear at its "end-of-life" for manufacturer security updates? What upgrades will you prioritize?

Incorporating New Sites and Equipment

You may later be able to acquire new sites with better vantage points for wireless gear.

- How will you integrate new locations, members, and equipment **both physically and organizationally** into your network?
- Can equipment at a site be moved if needed?

Assess existing infrastructure

Note that "Site acquisition," or finding and getting access to places to host equipment, can often be the hardest and/or most expensive part of building a community network. It typically takes the longest time and can depend heavily on community relationships and personal connections, especially on a low budget.

As you develop your network design, identify existing infrastructure that you can use:

Is there exising backhaul in the community?

Where is the closest IXP?

What information infrastructure is available locally (if any): telephone poles and lines, cable television lines, fiber–optic cables?

What land locations might be important for your network design? What buildings?

It is important to continuously look for opportunities to **build relationships with owners of useful existing infrastructure**, such as local backhaul providers, utility companies, people with rack space (i.e. server and data storage capacity) in IXPs or data centers, local tall building owners, and community resource hubs operating for public benefit such as schools and libraries.

You may also be forced to move sites over time, for example:

Due to future or ongoing construction that might create line–of–sight obstructions, the sale of a building.

Increased backhaul costs.

Changing community relationships, sponsorship agreements, etc.

Choosing the Right Technology

There are many different technology options for community networks, each with their own strengths and challenges.

Here are some common choices community networks are presented with:

Mesh or hierarchical network structure?

Mesh networks can be an affordable, accessible option for some community networks, especially those interested in **open source technologies.** Each user maintains a network "node" that acts as an internet connection to other users (connected with wire or wirelessly to one another). Imagine a network structured like a fish net, with nodes at the crossings. Typically all nodes are the same (i.e. in equipment, configuration, and maintenance), which can be helpful for developing a shared knowledge base and community of practice.

Mesh networks can grow incrementally and in an ad hoc way, with little coordinated planning: as new users join the network, the new nodes increase the network's coverage area and resilience. If one node breaks down, network traffic is rerouted automatically through alternative paths. Examples of software and firmware that support mesh functionality include **LibreMesh, Quick Mesh Project, and OpenWRT**. This firmware often needs to be installed on off-the-shelf routers, which is typically a finicky but doable process. An alternative is **LibreRouter**, an open hardware project where network nodes are designed with both hardware and software optimized for rural community mesh networks, but these devices are not yet legally certified to operate in many countries. There are other ways to configure mesh networks without open source software, which still requires a small amount of centralized coordination (**NYC Mesh** is an example, with very good documentation available online).

Most networks in the world have a hierarchical structure (like an upside–down tree) which route data to, from, and between the users (the leaves) through a "core" network (the branches and trunk). This can make routing simpler, more predictable, and higher performance (faster), sometimes at the expense of disaster resiliency. Examples include simple **access point networks** such as a standard high–power WiFi AP installed on a roof that anyone's laptop can connect to, or a **point–to–multipoint** (PtMP) 4G LTE network distributing internet access to hotspots throughout the community. These access points can then be connected "upstream" (i.e. linked together at a place in the network that is before users access data) to a core router via physical or virtual (e.g. VPN) network links if you want to combine them into a single network sharing one backhaul (like building branches from leaves to a shared trunk), but this is not strictly necessary for basic internet connectivity. Other examples are **GPON (fiber) networks** (i.e. Gigabit Ethernet passive optical network, a point–to–multipoint network technology that delivers broadband access to the end user via fiber optic cable).

If using wireless technologies, what frequency spectrum/type of radio should we use?

ISM

ISM band (Unlicensed) spectrum:
ISM radio bands are radio frequencies allocated internationally for industrial, scientific, and medical (ISM) purposes. These include the 5GHz and 2.4GHz frequency bands typically used by WiFi, and a 900MHz band often used for low-bandwidth communications such as sensor networks. These are the most common bands available for wireless ISP gear. PtP wireless radios are also available in 24GHz and 60GHz, more dependent on line of sight due to their higher frequency. The ISM bands are by far the cheapest options for wireless equipment.

TV White Space (TVWS, Unlicensed) spectrum: TVWS is an option most commonly used in rural wireless networks to cover long distances (often with lower bandwidths, in the tens to low hundreds of Mbps). TVWS transmitters utilize unused television spectrum to send signals. TVWS systems can be mesh networks or point-to-multipoint distribution networks. One advantage of TVWS is that you do not need line of sight to make network connections due to the use of low frequencies (470 MHz–790 MHz). **Lightly licensed spectrum:** In the United States, the Citizens' Broadband Radio Service (CBRS) spectrum at around 3.5GHz is another option, sometimes desirable because unlicensed bands can have a lot of interference (less of a problem in rural areas). To legally install devices in this band, you need someone with a **Certified Professional Installer (CPI) license**, which you can get by taking an online course/exam for a fee. You also need to pay for a subscription to a national database called a Spectrum Access Service (SAS) for spectrum coordination (usually a few dollars per device per month).

Resources

01. **Community Networks (2018) Association for Progressive Communication & International Development Reseaerch Centre.**
https://www.apc.org/en/pubs/global-information-society-watch-2018-community-networks

02. **Neighbourhood Network Construction Kit.**
https://communitytechnology.github.io/docs/cck/

03. **ILSR Community Networks**
https://communitynets.org/

04. **TakNet (a community network in Thailand that combines mesh network and TVWS technologies)**
https://blog.apnic.net/2019/07/01/

ISM bands
05. *https://en.wikipedia.org/wiki/ ISM_radio_band*

Design a Pilot Network

Working with the information gathered and decisions made in response to the network planning questions, design a feasible pilot network. Ensure:

01. Transmitters/repeaters/nodes have line–of–sight as required

02. Permissions for transmitters/repeaters/nodes locations are obtained

03. Appropriate tools & equipment are available

04. You have technical know–how through outside expertise, instructional content and/or community members.

The long-term feasibility of a community network will depend in part on addressing ongoing issues of maintenance and upkeep in a timely way. Consider creating longer term strategic plans for sustainability, including strategies for:

01. Ongoing awareness/evaluation of changing community needs

02. Network expansion to serve new areas / new users Equipment upgrade costs & planning

03. Maintain and build relationships with owners of infrastructure as the network expands

04. Capacity building and knowledge sharing

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BUILDING THE NETWORK

After putting the team together, establishing rules for inclusive and accountable decision–making, mapping and designing a workable network design that incorporates topographical and infrastructural limitations and advantages, it is time to build the network. **Consider building a pilot network first as proof of concept.** A pilot network is a much smaller and simpler version of the network you ultimately hope to build. A pilot network may only have a few nodes to begin with, a chance to learn about and to try new technologies, troubleshoot problems, and get familiar with technologies before inviting the public to join the network.
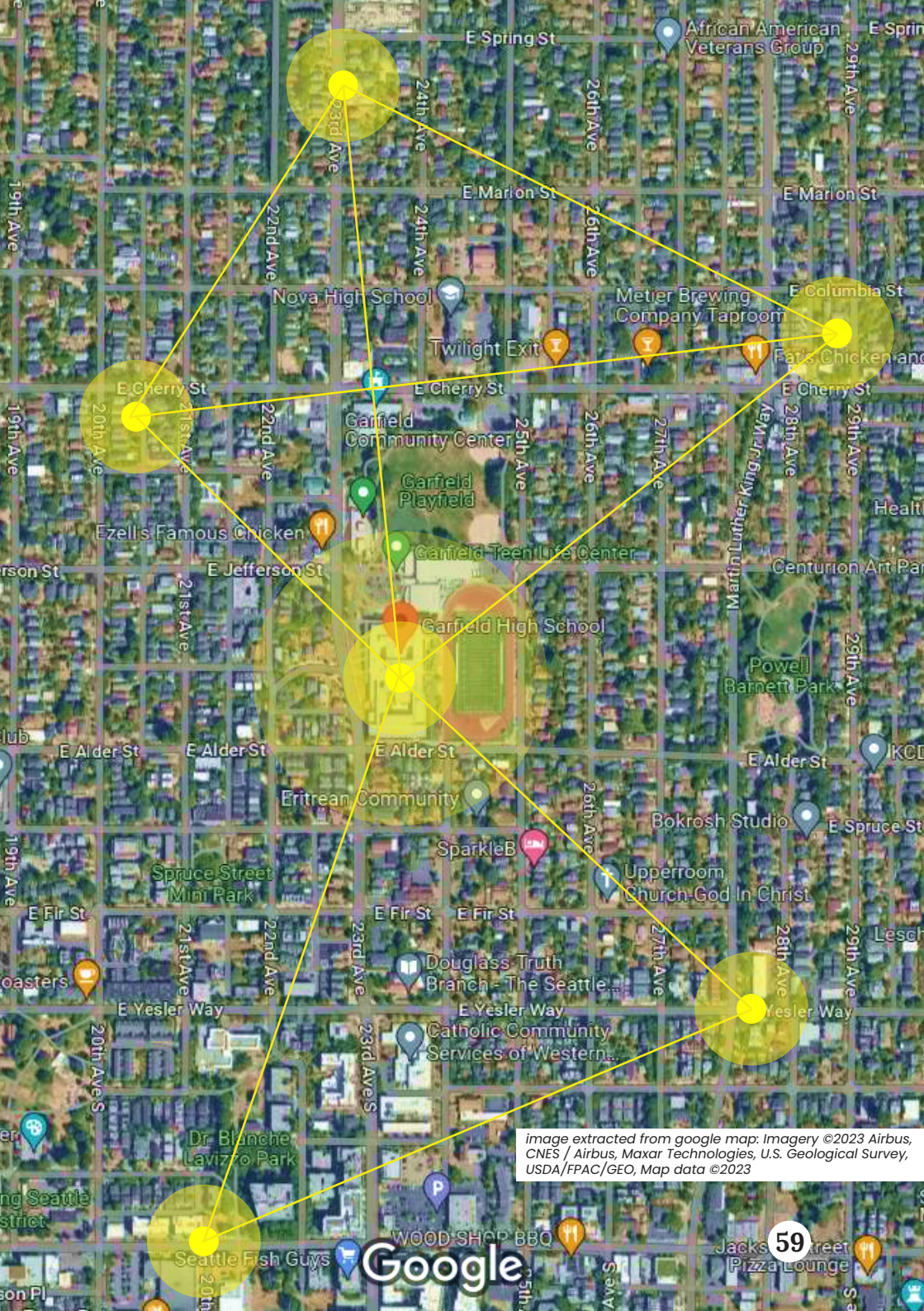
Here are some key tasks when building the network:

01. Determine the location for nodes and/or access points

02. Obtain necessary permissions and access

03. Obtain routers, nodes, transmitters, sofware, and tools

04. Install nodes

05. Conduct network testing

06. Optimize network performance

07. Troubleshoot and resolve issues

Once the initial network is up and running, consider organizing a community event to announce the network and invite community members to join.

Establish a 'steward' or 'referente' system which encourages more technically knowledgable network members to help others set up nodes and troubleshoot/learn to troubleshoot.

Develop a troubleshooting self–help archive to keep text and/or photo or video records of solutions to common technical problems. Encourage members to document their technical problems and solutions in the archive.

Some examples:
- Create a community wiki that members can add to as problems arise and solutions are found.
- Share troubleshooting stories in real time through a communication platform, for example a Slack, WhatsApp, or other internal chat group.
- Have members take photos of technical problems & solutions (before/after), and post them somewhere with text describing their problem and how it was solved.
- Create videos showing how problems are solved, and post them somewhere accessible.

Community Support

Create and offer workshops for new members that provide technical training, introduction to the network and its operations, identify different ways of participating, explain responsibilities and expectations. Ensuring community participation is one of the most important strategies for the long term success of a community network.

Establish a communications system/platform for network members to share experiences, plan, discuss problems, offer assistance and solutions. Examples of popular communication solutions include: Slack or Discord forums, discussion forums, WhatsApp message groups, etc. Choose something that is accessible for most community members.

A communications platform can help community members coordinate fun community–building and feel–good events as well as solve problems, which can improve network sustainability and resiliency. Community networks are built on human relation-ships, and maintaining those relationships should be encouraged as a priority. Use the network as an excuse to build community, and the community as the foundation to build and expand the network.

At the same time, it can be a powerful learning experience for people to troubleshoot and resolve their own problems when possible, rather than immediately asking for help. Encourage an ethos of DIY, knowledge sharing and contribution. Consider establishing norms/practices of thanking, com-mending, or rewarding people publicly for shar-ing and documenting DIY activities or solutions to problems, or for helping others resolve their prob-lems. The communications platform can be used to help facilitate this.

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FREQUENTLY ASKED QUESTIONS

Is building a community network expensive?

Building a community network does not have to be expensive. You can even build a community network without money, making use of donated labor and resources you might already have in your local environment such as old routers, e-waste, open-source software, and repair or construction skills. However, these more "scrappy" options may require more knowledge and experience to implement. The costs will also depend heavily on the technology you choose. For example, fiber-optic networks can be extremely expensive to build, but can provide faster and more reliable network service in the long run with fewer maintenance costs. Unlicensed wireless frequencies and equipment (marketed for

small "WISPs") can be orders of magnitude cheaper than licensed and simpler to manage and configure, but can have other drawbacks such as vulnerability to interference, weather–dependent performance, or potential to run out of spectrum. See *Chapter 2, Governance and Finances section (page 30)* for more on cost considerations, and *Chapter 3, (page 32)* for technology options.

How hard is it to learn the technical skills required to run a network? Where can I learn them?

It depends on the technology you're using! Learning by hands–on experience is by far the best way to learn networking, however different technologies will also have very different learning curves. But the basic skills required to set up and run a local network can be learned by both adults and youth with access to resources and tools, time and patience. See *Chapter 3, (page 32)* for on different technology options for CNs and to access further learning resources.

Where can I access topographical maps of my region for network planning?

Many modern computer–based mapping tools such as Google Earth Pro come pre–loaded with satellite–based and other types of topographical data (such as LIDAR, which means Light detection

and ranging sensing technologies used to mea-
sure elevation data), with which you can easily run
a "viewshed analysis" to find out what you can see
from a given point, i.e. to map.

**What are some good strategies for getting com-
munity members involved and on board?**

Community networks, like any community–build-
ing initiative, benefit from activities and structures
that bring people together regularly in rewarding
and enjoyable ways (think clubs, sports teams or
religious establishments). Social events and cozy
gatherings, planning and decision–making meet-
ings, and skill share or work sessions all have their
place in an ecosystem of support and collabo-
ration. It can be helpful to give participants goals
to work towards, and a way to "buy in" or commit
to joining the network, whether through building
and installing their own node, or through working
towards membership via a series of completed
trainings or tasks. To gain more public communi-
ty presence, classic outreach and publicity tech-
niques such as door knocking, canvassing, and
handing out or mailing fliers to tell people about
your initiative can also be effective. Use outreach to
bring people to in–person meetings where they can
meet the community and see for themselves what
joining the network will look like.

Do we need to incorporate a company or organization to run a community network?

No, you don't. However, incorporation may help you in the long run for things like raising and holding funds to support your network, advocating politically, hiring people, and establishing a public presence. For example, having registered nonprofit or cooperative status may help with specific types of funding or financial management. We would encourage you to build your team and community, letting your shared values and goals shape the organization you incorporate. See *Chapter 2, (page 14)* for more on organizing your network.

Intranet v. Internet: Which is better?

It depends on your goals! If you are interested in connectivity to the outside world, accessing remote websites, information, and services such as WhatsApp, Google, and Facebook, you will need access to the Internet (also known as backhaul). You will typically (but not always) have to pay for this kind of "upstream" connection that can carry your data anywhere in the world. In contrast, an Intranet is a local network that can connect different places or machines inside your physical community (via wireless or wired links). You can use the Intranet for sharing resources and data internally—for example, you can host a local website about

your community's culture, language, and history that students can access from connected locations, such as their school, library, or home. You can also share resources from the Internet through an intranet network, thus reducing Internet access fees. You can often run an Intranet for very low cost, and you don't have to pay or charge money for these services unless you want to. You do not have to connect an Intranet to the wider Internet (e.g. make your website available to the rest of the world), unless you want to. You can provide both an Intranet and Internet service in your community at the same time.

Will the network be free for community members or should we charge a fee for access?

The pricing structure is up to you. Charging fees for access is a valid way to encourage member "buy-in" and commitment, keeps income flowing into the network to cover operational and maintenance costs, and can keep network operators accountable for the quality of service they provide. However, some communities may choose to focus their network projects on serving those who cannot afford to pay for access, pushing them towards a nonprofit model where they do not charge users. These networks may need to constantly fundraise from external sources to cover unavoidable maintenance costs. Some networks operate on a suggested

donation, pay–what–you–can, or sliding scale model for user contribution. Networks can also operate using a hybrid or tiered approach–for example, offering a free limited bandwidth service and charging fees for faster or more data capable services. You may also want to consider asking members to contribute labor, time, skills training, or other alternatives which can be just as valuable as money in a community network's operations. See *Chapter 2, Governance and Finances section (page 30)* for more on financial sustainability and organizational models.

How much work / how much time does it take to run a community network? What about my work / life balance?

Finding work/life balance while running a community network is an important and common question, especially if there is a small core team running the network compared to the total number of users or the geographic reach of the network. Operating critical infrastructure that people depend on can feel overwhelming at times, and can realistically take up as much space in your life as you let it. When network outages happen, users may urgently need assistance. It is up to you as a group to establish sustainable community practices for providing that help without overburdening or burning out any members. The network should remain resilient to

the ebb and flow of people's capacities and changing life circumstances.

You should establish realistic boundaries and reasonable expectations among users for how quickly problems can be resolved based on your available resources. For example, in a free, non-profit, volunteer-based network, you may have a member agreement that new joiners sign stating that services are provided on a best-effort basis, and outlining the user's own responsibilities to help maintain their own node. To support this, you will want to have robust troubleshooting resources online, on paper, and/or through workshops. Users who pay for Internet access will typically be more demanding. For a well-maintained and functional network, a realistic time estimate is the equivalent of at least one person contributing a full-time job's worth of mental and physical energy to the project. This can be shared by a few leaders contributing smaller amounts of time and energy, as long as they are well organized, committed, and work well together at sharing responsibilities and accountability. Passion and conviction among the network mobilizers are important, but these alone are not sufficient. It can be tempting to rely too heavily on individual "all-stars," but these members can also have their own needs to care for and their own limitations. Reliability and resilience depends on broader team capacity building and participation.

Many community networks cultivate a culture of DIY to encourage people to solve their own technical problems or work with their neighbors on local issues, activities which can solidify the practice of collaborating as well as help users acquire technical knowledge through experience. We recommend a shared communications platform where network members can reach out to the group for help and status updates. It can be crucial to recruit and maintain (often through continuous teaching and training) a large enough community of technicians, be they fellow users, employees, volunteers, or other. Especially invaluable are those who are reliable, responsive communicators, even when remote, and who enjoy helping others with their problems. Also invaluable are those with flexible schedules who are ready and eager to spring into action, and can shift other obligations around to prioritize network emergencies (e.g. people between jobs, those with flexible work–from–home jobs, elders who are retired, students on summer break, etc). While in–person site visits are sometimes needed, remote support over the phone or chat can often be just as effective and necessary, and provide those with limited mobility meaningful ways to participate. See *Chapter 2, Leadership and Organizing section (page 20)* for more strategies on maintaining sustainable membership, processes, and communications.

06

REFERENCES

Chapter 1

- Guifi.Net: *https://guifi.net/en*

- Rhizomatica: *https://www.rhizomatica.org*

- Zenzelini.Net: *https://zenzeleni.net*

- Freifunk.Net: *https://freifunk.net*

- New York City Mesh: *https://www.nycmesh.net*

- AlterMundi.Net: *https://altermundi.net*

- Wireless for Communities: *https://wforc.in*

- Seattle Community Network: *https://seattlecommunitynetwork.org*

Chapter 2

- Community Network Readiness Assessment Course (Internet Society): https://www.internetsociety.org/learning/community-network-readiness/

- Community Networks Training Webinar (Internet Society): https://www.internetsociety.org/events/indigenous-connectivity-summit/2021/trainings/community-networks-webinar/

- Community Networks Learning Repository: https://cnlearning.apc.org

Chapter 3

- Lesson 6 – Designing a Network – Aug 1: https://bit.ly/ds-lesson-designing-wireless

- Line of sight Image Refrence: https://www.crows-nestbb.net/how-it-works.html

- Inventory the Neighborhood: https://com-motionwireless.net/docs/cck/planning/inventory-the-neighborhood/

- Google Earth Pro: https://www.youtube.com/watch?v=ad7bMGPDwcw&list=PLZ1cQ-u1X-TA7nkhdE5XfUFLCEBfUbkt0x&index=6

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- TakNet (a community network in Thailand that combines mesh network and TVWS technologies): _https://blog.apnic.net/2019/07/01/_

- ISM bands: _https://en.wikipedia.org/wiki/ISM_

Additional Resources

- "Learn" pages for technical networking topics maintained by Network Startup Resource Center (NSRC): *https://nsrc.org/videos*

- Learning resources for US Tribal ISPs: *https://tribalresourcecenter.net*

- Global Community Networks Discussion Forum: *https://communitynetworks.group*

- Crowdsourced Community Networks Learning Resource List (Please Comment): *https://bit.ly/cn-resource-list*

- ISOC Spectrum Policy Brief: *https://www.internetsociety.org/policybriefs/spectrum/*

***Scan the QR code for the ongoing updated version of the roadmap.
https://bit.ly/cn-roadmap-web***

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The Community Network Roadmap is a tool designed to help communities create their own broadband network solutions for connectivity. From community organizing, to network planning, building out the network, technical training, organizational stability, community inclusivity and accountability, and growing the network into a long term, sustainable enterprise, this roadmap offers a comprehensive guide for the community network development process.

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(*https://bit.ly/cn-roadmap-web*)

Scan the QR code for the ongoing updated version of the roadmap.