Spectrum Approaches for Community Networks

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Introduction

The Internet Society's goal is to make the Internet available for everyone, everywhere.[i] The Internet currently reaches three (3) billion users, meaning that over half of the world's population remains offline.[ii] This connectivity "gap" is even more pronounced in urban, rural, and remote unserved and underserved areas of many countries, particularly developing and least-developed countries.[iii] Historically, this includes the challenge of extending infrastructure and affordable services to end-users (often times referred to as the problem of "the last mile"), and the challenge of attracting people online.

Factors that contribute to these challenges are well understood: low population density, high deployment costs, low economic capacities of some populations, limited availability of locally relevant content, and issues with technical skills.[iv] The connectivity "gap" needs to be closed. By closing this gap, economic and social benefits can be brought to communities across the globe.[v] One way to help close the gap is through community-based connectivity projects[vi], particularly through community networks.

To truly connect everyone, everywhere, community networks must be recognized as a viable alternative way for the unconnected to connect their communities. This is a paradigm shift where the focus is on allowing communities to actively connect themselves. To achieve this paradigm shift, policy makers and regulators should recognize that connectivity can happen from the "village" or "community" out – where the last mile is essentially a "first-mile". Community networks offer a complementary—not competitive—alternative to traditional, commercial telecommunications networks.

Policy and regulatory factors to enable community networks to succeed include, innovative licensing, funding opportunities that can include, but are not limited to traditional universal service funds (USF), and access to spectrum. The focus of this paper will be on the importance of enabling access to spectrum.[vii] including utilization of currently unused spectrum.

Key Considerations

What are Community Networks?

A community network starts with a local group of people who want to bring communications to their local village or town or who want to enable communications for other local services. This group or "community" may grow over time as interest develops in changing local circumstances. The local community network generally is a "local community join[ing] together to pay for the common infrastructure based on the value realized by the community as a whole."[viii] Community networks are built and operated by people in the community; they are the result of people working together, combining their resources, organizing their efforts, and connecting themselves. These networks are often small in scope, usually serving communities under 3,000;[ix] but, some serve more than one village or community. For example, guifi.net, a community network located predominantly in Spain, and with nodes in Africa, Asia, Latin America, and Portugal, is estimated to serve more than 50,000 people.

From an infrastructure perspective, some community networks rely on wireless and optical fiber technologies, and often feature a distributed architecture.[x] For example, some networks are Wi-Fi only, others are mesh networks, and some are simple 2G networks providing Voice over IP services (VoIP). From a regulatory and policy perspective, community networks change the focus on "the last mile"; these networks, built from the "bottom-up" are "the first mile"[xi] not the last mile. This means that connectivity starts in a community.

Experience has shown from existing community networks that there are numerous benefits to the community. The cost to deploy community networks can be low. Often, the technology required to build and maintain the network is as simple as an off-the-shelf wireless router.[xii] In other cases, it is more difficult and requires changes to firmware, hardware and software. The bottom-up organization of community networks yields benefits and local buy-in as well, including:

- Providing service that is tailored to the unique needs of the community;
- Empowering local people, and thereby encouraging involvement in other grassroots efforts, community affairs, and political processes;
- Encouraging digital literacy;
- Providing a "stepping stone" for people to become part of the global economy;
- Creating new working opportunities; and
- Promoting the virtuous cycle by improving both access to and creation of local content and services.[xiii]

As noted earlier in this brief, community networks are not competitors to traditional networks. Instead, they provide local access where traditional or commercial networks do not reach or serve particular areas, or where commercial operators do not find it economically viable to operate in particular areas. They represent a viable alternative to connecting areas "that are unattractive to telecommunication operators and governments."[xiv]

We believe that community networks should be viewed as an alternative connectivity option that provides access to people, where, as mentioned earlier, a network is built *in* and *for* that local area. For the most part, the areas that benefit from community networks would be ones that were previously unconnected, or they are communities where connections were unaffordable. Where traditional networks with limited services

do reach such communities, community networks can serve as complements—not competitors—to traditional networks.

The Critical Importance of Access to Spectrum

It is widely recognized that access to information and communications technology ("ICT") creates social and economic benefits. This is reflected in the United Nations Sustainable Development Goals, which includes "significantly increas[ing] access to [ICT] and striv[ing] to provide universal and affordable access to the Internet in least developed countries by 2020."[xv]

ICTs provide the basis for opportunity and success in today's global economy, and enable critical social benefits, as well. From e-commerce to e-health, from emerging industries and technologies to distance learning, from social and political engagement to public safety, ICTs provide the backbone of modern-day societies.

Access to affordable and available spectrum is a foundational principle for ensuring access to ICTs and future network development. For every community to reap the social and economic benefits of ICTs, policy makers must ensure that adequate spectrum is available for community networks and other entities seeking to develop networks and provide access to ICTs. Ensuring adequate spectrum will be the difference between new ICT applications flourishing or languishing, and will be the difference between community networks providing much needed access to under-served communities. Without spectrum, communities will not benefit from modern-day developments.

Challenges

Ensuring access to spectrum is a significant challenge[xvi] to connecting unconnected areas via community networks. Community networks critically rely on the availability of spectrum; the scarcity of spectrum threatens the network's ability to operate and deliver services.

Ensuring that adequate spectrum is available for community networks is a key policy principle for expanding Internet access. However, there are several challenges that stand in the way of alternative networks like community networks having adequate access to spectrum:

- ***Spectrum is scarce.*** Spectrum is a finite resource, and accordingly, regulators must manage its use efficiently and effectively.
- ***Traditional regulations have led to inefficient use of spectrum.*** Regulators often favor exclusive and broad licenses, leading to the inefficient allocation and use of spectrum.

Exclusive Licenses: Traditional licensing favors exclusive use, as opposed to shared use. Exclusive use licenses provide one licensee unfettered use of a particular swath of spectrum. This can result in large portions of spectrum being unused or underutilized.
Broad Licenses: Many licenses cover large geographic areas; however, the incumbent service providers that have the rights to these broad licenses may not have the economic incentives to build out their networks to utilize fully all of the spectrum licensed to them. This also can result in large portions of spectrum being unused or underutilized.

- ***Access to spectrum is expensive.*** Spectrum rights come at high costs. For example, many regulators auction spectrum rights to the highest bidder, and

many charge high regulatory fees for spectrum. Often, community networks do not have the funding or financial ability to pay for spectrum rights. What is more, because incumbent service providers have made sizeable investments in obtaining spectrum rights, they often have an expectation of exclusive use of that spectrum that is difficult to combat.

Guiding Principles

To close the gap between *more connected* urban areas and *unconnected* rural areas, policy makers are urged to consider the benefits of community networks, and ensure that these networks have adequate access to spectrum. Below are a number of ways that community networks may gain access to spectrum. Policy makers should look to these examples when considering how community networks can allow the unconnected to connect.

Utilizing Unlicensed Spectrum

Unlicensed spectrum is spectrum that is not tied to a regulatory license. Users may utilize this spectrum with minimal regulatory requirements, and without the need to pay the high costs of obtaining a spectrum license.

Examples of community networks utilizing unlicensed spectrum include:

- **Chancay-Huaral Project**—The operations of the Chancay-Huaral Project in Peru in the 2.4 GHz band were confined to indoor spaces and were subject to strict power restrictions. To build the community network, the project obtained special permission from the regulator.[xvii] Taking this regulatory step was critical to the project and represented a step-forward in collective collaboration between the project and the regulator to enable connectivity.
- **guifi.net—**guifi.net, predominantly located in Spain with nodes in many regions, is the world's largest community network. As of December 2016, guifi.net boasted more than 32,500 operating nodes, serving more than 50,000 people. Wi-Fi was the first technology to be used in the network, and remains the most popular.[xviii]
- **Pamoja Net**—This community network is located on the island of Idjwi in the Democratic Republic of Congo. The island was largely unconnected—it was difficult to even place calls or send texts from the island to the mainland. With wireless technology, Pamoja Net provides public access Internet on the island on a pay-as-you-go basis. As of Fall 2016, Pamoja Net had over 200 users per month.[xix]
- **Wireless for Communities (W4C)—**The Digital Empowerment Foundation (DEF), partnering with the Internet Society, runs a program called Wireless for Communities (W4C). Launched in 2010, W4C started with helping to create wireless mesh networks in three communities in India; today, it has helped to build community networks in over 100 communities across India, Nepal and Pakistan. These community networks use low-cost Wi-Fi equipment to utilize unlicensed spectrum bands (2.4 GHz and 5.8 GHz). Importantly, W4C focuses on rural and remote communities where traditional commercial networks do not reach—telecom dark areas. The W4C project has been made possible by the government not requiring operators in the 2.4 and 5.8 GHz bands to obtain a license to use the radio spectrum.[xx]

Sharing Licensed Spectrum/Dynamic Spectrum Access

Recent technological developments have opened the possibility of sharing spectrum, which would allow community networks in rural unserved or underserved areas to use already-licensed spectrum on a secondary basis.[xxi] An example of this is using the "unused" spectrum in the television bands—known as television white spaces (TVWS)—to provide Internet access.

Examples of sharing licensed spectrum in unserved or underserved areas include:[xxii]

- Citizen Connect—Microsoft has backed numerous TVWS initiatives, including Citizen Connect in Namibia, which has successfully connected large portions of northern Namibia. Microsoft has described that "[t]he ultimate plan is to provide a network of broadband internet connectivity across the country, utilizing the unlimited potential of White Spaces broadband."[xxiii]
- Cape Town TVWS Trial—Google backed the Cape Town TVWS Trial in South Africa in 2013. The trial utilized a database that calculated channel availability so as to avoid harmful interference; there was no measurable interference during the trial. The resulting recommendations included urging regulators to implement policies that would enable TVWS devices.[xxiv]
- Project Kgolagano—Microsoft also backed a TVWS pilot project in Botswana. This project, launched in 2015, aims to provide internet connectivity and telemedicine services to local hospitals and clinics. This project was specifically authorized by the regulator in Botswana.[xxv]
- TVWS Experimental Licenses in India—In 2016, the Indian government issued 8 experimental licenses in the 470-582 MHz band to carry out experiments of TVWS-type rules and regulations.[xxvi]
- Malawi TVWS Pilot Network—In Malawi, the regulator partnered with a university to conduct a TVWS trial, connecting hospitals and schools in rural areas where there is "unavailability or poor broadband performance from the currently available commercial ISP services." The results showed that TVWS in the UHF band demonstrated 2.6 times better data rates than other fixed broadband services.[xxvii]

Innovative Licensing

Untethering spectrum rights from the traditional models of licensing also presents an opportunity for community networks to gain access to spectrum. One example of innovative licensing is a "social purpose" license[xxviii], which is an exclusive service license granted in rural unserved or underserved areas to non-traditional network operators, such as community network operators. With "social purpose" licenses, regulators set aside specific licenses for non-traditional operators, which removes the competitive nature of licensing, and prioritizes spectrum use for non-commercial purposes.

The following examples of innovative licensing, including the use of "social purpose" licenses, are instructive:[xxix]

- India—A recent Supreme Court decision held that "spectrum, such as TV white spaces (TVWS) or 5GHz spectrum, could be allocated on a license-exempt or unlicensed basis as long as such a policy is 'backed by a social or welfare purpose' such as using connectivity to increase social and economic inclusion."[xxx]

- Mexico—Mexico's regulator has set aside two 5MHz bands (824-849 and 869-894 MHz) specifically for social purpose use. To use these bands, the community served must be less than 2,500 people, or be an indigenous region or otherwise designated for such use. Since the introduction of these social purpose licenses,

> Rhizomatica, an organization that creates community owned and operated networks in rural Oaxaca, Mexico, has taken advantage of the new regulations for the benefit of more than 10 rural communities.[xxxi] Rhizomatica's founder, Peter Bloom, said this of Mexico's adoption of Social Purpose licenses:

Rural areas have traditionally been no-go areas for incumbent telcos, and this forward-looking approach by the [Mexican regulator] allows other actors, including the communities themselves, to provide affordable access to communication services by having direct access to spectrum. This will lead to more people being connected which will bring both social and economic benefits to underserved areas. If the role of regulators is to maximize the benefit that society obtains from the use of radio spectrum, then this is a step in the right direction.[xxxii]

Experimental licenses are also another key way for community networks to obtain access to spectrum. These licenses allow regulators and policy makers to make gradual changes in the way they facilitate development of communications in formerly unserved and underserved communities.

Recommendations for Community Networks:

The recommendations below are focused on actions that some community networks have taken. These recommendations are meant to be considered 'food for thought" for community networks to help shape a more innovative policy and regulatory environment to enable and support their efforts:

- **Reach out to Existing Community Networks for Advice**: Create your own "human" network by reaching out to existing community networks to ask them how they created change. We have found that community networks are keen to share their experience with others.[xxxiii]
- **Engage with the Regulator or Ministry in your Country**: Change starts with dialogue to create that change. By engaging with and educating policy-makers and regulators, community networks can educate and also learn how to change current policies and regulations.
- **Attend Local, Regional, and International Community Network Events**: Training, sustainability, and informational events for community and local access networks exist in many countries, regions, and globally. These convening events should not be underestimated as they have created local and national partners, and created "real time" networks to help sustain networks and obtain project funding.
- **Work with Existing Anchor Institutions:** Existing anchor institutions (e.g., health centres, libraries, and schools) can be key allies and provide space for training, network hosting, and local content development.
- **Engage with Internet exchange point (IXP) and network operator group (NOG) communities** as they are bottom-up community based, and help build bottom-up community based infrastructure

Recommendations for Policy Makers and Regulators

The recommendations below are focused on actions that policy-makers and regulators can take to begin to shift mind-sets to consider community networks a viable alternative form of connectivity. It is important that communities collaborate with policy makers as

they have a key role to play in identifying their specific needs and in explaining how these can be best served. It is important to note that these recommendations are not meant to be exhaustive, but to start the conversation to enable innovative regulatory and policies to:

- *Increase Regulatory Transparency*: Regulators should ensure that their rules are publicly available and that they are easy to understand and to access. Regulatory transparency will provide organizations the certainty they need to make investments in community networks. One way for regulators to achieve regulatory transparency is to hold public meetings and to publish their rules and regulations online.
- *Ensure Regulatory Fairness:* Regulators should abide by regulatory "best practices" and commit that rules and regulations will be clearly established and followed. Ensuring that regulators do not act in an arbitrary or capricious way will increase investments, from both traditional networks and alternative networks. It will also help to reduce traditional operators' reservations regarding new and innovative spectrum management tools.
- *Increase Regulatory Flexibility:* Regulators should consider non-traditional spectrum management tools in an effort to better utilize scarce spectrum. Several such tools are described above in the *Guiding Principles* section, including

Utilizing unlicensed/licensed-free spectrum: To promote community networking opportunities, policy makers should ensure the availability of unlicensed, Wi-Fi spectrum, and regulators should fully exempt Wi-Fi spectrum from licenses and fees. While many countries have forward-thinking Wi-Fi policies, many do not.[xxxiv] While policy makers should continue to understand the value of licensing spectrum,[xxxv] they should also ensure the availability of unlicensed spectrum.

Sharing Licensed Spectrum/Dynamic Spectrum Access: Policy makers should allow and create incentives for spectrum sharing. To overcome hesitance on the part of incumbents to engage in sharing, policy makers should help to ensure, among other things, that each spectrum user has clearly defined rights and obligations, and that the multiple uses of the spectrum are compatible.[xxxvi] To further promote the efficient use of spectrum, policy makers could require sharing where licenses are not fully built-out; allow networks to achieve build-out milestones via sharing; consider a reduction in regulatory fees or an extension of a licensing term for operators who share; or adopt similar incentives to prevent idle spectrum.

Innovative Licensing: Policy makers should consider innovative licenses to enable community networks to have access to spectrum. In granting innovative licenses, regulators should recognize that community network operators and other non-traditional operators are different than traditional operators, and require an easy, transparent, and streamlined process for obtaining licenses, with less severe technological requirements. Regulators should also not limit non-traditional operators from engaging in more traditional commercial activities, such as utilizing advertising to finance operations. Regulators should consider including community network experts on regulatory policy-making advisory panels to help bring increased perspective to policy and regulatory decision-making.

- *Lower Costs of Spectrum Based on Special Circumstances:* As discussed, there are high costs associated with spectrum rights. High spectrum fees and auctions

present challenges for non-traditional operators. Regulators should consider reducing these costs for operators like community network operators, either through bidding credits where spectrum rights are auctioned, or reduced spectrum fees.

Recommendations for Network Operators

Additionally, network operators[xxxvii] can and should help community networks both access spectrum and put that spectrum to use in connecting the unconnected. To do so, network operators should:

- ***Enter into Roaming Agreements with Community Networks at Fair and Reasonable Rates:*** For community networks' users to have a seamless service experience, it will be important for community networks to enter into roaming agreements with network operators where the community network does not reach. Many carriers should enter into these agreements at fair and reasonable rates, taking into consideration the unique mission and role of community networks.
- ***Equipment and Training Partnerships:*** From a future network user perspective, network operators may find that partnering with community networks – training or equipment partnerships – builds stronger future communities. Partnerships like these strengthen human and technical infrastructure and builds future digital skills/citizens in communities.
- ***Share Spectrum:*** One way that network operators can help community networks access spectrum is to be open to sharing their own spectrum. Traditional network operators and community networks could enter into independent spectrum sharing agreements that clearly define each party's rights and obligations. Another way to support community networks is for network operators to be supportive of them as an alternative and legitimate form of connectivity, particularly when asked by regulators and policy-makers about their importance and the need for sharing, secondary, or license-free use of spectrum.
- ***Make Backhaul Available to Community Networks at Fair and Reasonable Rates:*** Backhaul infrastructure is critical to connect traffic from the community network to regional and larger global networks. Access to such infrastructure can be costly. There are a number of new technologies and methods to reduce the traditional backhaul expense;[xxxviii] however, access to the backhaul infrastructure of network operators could greatly benefit community networks. Network operators should consider making their backhaul available to community networks at fair and reasonable rates.
- ***Give Special Consideration to Community Networks Regarding Interconnection Agreements:*** Interconnection is key to the success of community networks, as it allows communications from a single community network across other networks, truly connecting the unconnected. Network operators should enter into interconnection negotiations with community networks understanding the unique mission and role of these entities, and should be sensitive to the fact that many community networks may not have the background or legal resources that other carriers might. Many carriers should be willing to offer community networks minimal interconnection fees that are fair and reasonable.

Additional Resources

Amelia Yeo, *Wireless For Communities (W4C) – Best of a breed*, Internet Society (June 18, 2015), https://www.internetsociety.org/blog/asia-pacific-bureau/2015/06/wireless-communities-w4c-best-breed.
Jane Coffin, *Bringing the world online*, Internet Society Blog (June 24, 2016), https://www.internetsociety.org/blog/community-projects/2016/06/bringing-world-online-meet-people-who-are-making-it-happen.
A Policy Framework for Enabling Internet Access, Internet Society (Sept. 14, 2016), http://www.internetsociety.org/doc/policy-framework-enabling-internet-access.
Jane Coffin, *You Can Build the Internet*, Internet Society Blog (Dec. 2, 2016), https://www.internetsociety.org/blog/development/2016/12/you-can-build-internet.
Osama Manzar, *Build the Internet: Training Barefoot Network Engineers*, Internet Society Blog (Dec. 2, 2016), http://www.internetsociety.org/blog/development/2016/12/build-internet-training-barefoot-network-engineers.
First Summit on Community Networks in Africa, Internet Society (Feb. 21, 2017), https://www.internetsociety.org/events/first-summit-community-networks-africa.
Dr. Carlos Rey-Moreno, *Supporting the Creation and Scalability of Affordable Access Solutions: Understanding Community Networks in Africa*, Internet Society Report (May 2017).

[i] The Internet Society's goal supports the United Nations Sustainable Developments Goal of achieving universal and affordable access to the Internet. *See* Sustainable Development Goal 9, United Nations Sustainable Development Goals, https://sustainabledevelopment.un.org/sdg9.

[ii] *Internet Society Global Internet Report 2015: Mobile Evolution and Development of the Internet*, Internet Society, at 9, 119 (2015) ("*Internet Society Global Internet Report 2015*").

[iii] Land-locked developing countries (LLDCs) and small island developing states (SIDS) are included here in this definition.

[iv] *See* Leandro Navarro, et al., *Advances in Wireless Community Networks with Community-Lab Testbed*, at 1 (2016), http://dsg.ac.upc.edu/node/734.

[v] *See Internet Society Global Internet Report 2015*, at 9 (describing the benefits of the mobile Internet).

[vi] Local access projects of all kinds are a key way for communites to connect. Community networks are a type of local access project.

[vii] The focus of this brief is on spectrum options for community networks. Access to spectrum is one of many factors that can help minimize digital divides. Innovative regulatory options like use of Universal Service Funds (USF) or experimental licensing are some additional factors that can help. One example of policy makers utilizing USF to aid community networks is in the United States, where USF funds are available to

community networks (also known as cooperatives). For example, the Community Connect Program provides grants "[t]o promote broadband service in extremely rural, lower-income American communities where it currently does not exist, and to promote 'community-oriented connectivity' that would stimulate economic development and enhance educational and health care opportunities." *Lands of Opportunity: Bringing Telecommunications Services to Rural Communities,* FCC (July 2006), https://www.ruralcenter.org/sites/default/files/Ruralbook120204%5B1%5D.pdf. These grants are available to Indian tribes and tribal organizations, and cooperatives, among other types of entities. *Id.*

[viii] *Community Connectivity: Building the Internet from Scratch,* Annual Report of the UN IGF Dynamic Coalition on Community Connectivity, at 11 (Luca Belli ed., Dec. 2016), http://bibliotecadigital.fgv.br/dspace/handle/10438/17528 ("*Community Connectivity*").

[ix] *Id.* ("We go there because no private, cooperative or state telecommunications agencies are concerned with providing internet access in these places. They are always the last priority and their turn never comes around. Also, it's much easier to build a community network in a small town than in a big city.").

[x] *Id.*, at 8, 34, 61 & n.45, 112; *Broadband in Brazil: Past, Present and Future*, at 137 (Peter Knight, et al. eds., 2016), https://www.academia.edu/30187528/Broadband_in_Brazil.pdf?auto=download; Roger Baig, et al., *guifi.net, a crowdsourced network infrastructure held in common*, Computer Networks, at 8 (2015), http://dx.doi.org/10.1016/j.comnet.2015.07.009; Lelia Nachawati, *AlterMundi: "Community networks embody the original spirit of the internet"*, Association for Progressive Communications (Nov. 23, 2015), https://www.apc.org/en/node/21346/

[xi] "'First Mile' refers to the development of local telecommunications infrastructure that benefits local communities, in contrast to how local infrastructure is often referred to as 'last mile' development that benefits centralized, urban-based telecom corporations and governments." *Indigenous People and Mobile Technologies,* at 111 (Laurel Evelyn Dyson et al., eds.) (2015).

[xii] *See* Roger Baig, et al., *guifi.net, a crowdsourced network infrastructure held in common*, at 1.

[xiii] Aaron J. Meyers, *Improving Access to Telecommunications in Rural Area of Developing Countries: Consumer Cooperatives and the Millennium Challenge Corporation*, Institute for International Law and Justice, at 2 (June 17, 2008), http://www.iilj.org/wp-content/uploads/2016/08/Meyers-Improving-Access-to-Telecommunications-in-Rural-Areas-of-Developing-Countries-2008.pdf; Dr. Carlos Rey-Moreno, Supporting the Creation and Scalability of Affordable Access Solutions: Understanding Community Networks in Africa, Internet Society Report (May 2017); *Community Connectivity*, at 33

[xiv] Dr. Carlos Rey-Moreno, Supporting the Creation and Scalability of Affordable Access Solutions: Understanding Community Networks in Africa, Internet Society Report (May 2017).

[xv] Sustainable Development Goals, United Nations, https://sustainabledevelopment.un.org/post2015/transformingourworld.

[xvi] There are a number of other challenges facing community networks that are not covered by this policy brief.

[xvii] Hernan Galperin, *Wireless Networks and Rural Development: Opportunities for Latin America*, MIT, Information Technologies and International Development, at 51-52 (2005).

[xviii] *Guifi.net – The technological project*, guifi.net (Dec. 19, 2016), https://guifi.net/en/technological-project ; Davide Vega D'Aurelio, et al., *A technological overview of the guifi.net community network*, Computer Networks (2015)

[xix] *Pamoja Net—A Community Commons*, Project First Light (Sept. 22, 2016), https://firstlight.fjordnet.com/pamoja-net-a-community-commons/; *Bringing the Internet to Africa's Forgotten Island*, Fjordnet.com, https://www.fjordnet.com/workdetail/bringing-the-internet-to-africas-forgotten-island/.

[xx] Wireless for Communities, Digital Empowerment Foundation, http://wforc.in/; Satya N. Gupta et al., *Unlicensed Spectrum Policy Brief for Government of India*, The Centre for Internet & Society, at 14 (June 24, 2012), http://cis-india.org/telecom/unlicensed-spectrum-policy-brief-for-govt-of-india ; Osama Manzar, *Build the Internet: Training Barefoot Network Engineers*, Internet Society (Dec. 2, 2016), https://www.internetsociety.org/blog/development/2016/12/build-internet-training-barefoot-network-engineers.

[xxi] Spectrum that is licensed to a particular user (the primary user) can be utilized by another user (a secondary user) when the primary user is not utilizing the spectrum. Secondary uses of spectrum are variable, and can include geographic sharing or temporal sharing.

[xxii] These are examples of TVWS technology being used to connect the unconnected. Spectrum sharing, however, should be viewed as one way that policy makers can enable community networks to have access to spectrum.

[xxiii] White Spaces Database, Microsoft, http://whitespaces.microsoftspectrum.com/

[xxiv] *Studies on the Use of Television White Spaces in South Africa: Recommendations and Learning from the Cape Town Television White Spaces Trial*, Tertiary Education and Research Network of South Africa, at 7, http://www.tenet.ac.za/tvws/recommendations-and-learnings-from-the-cape-town-tv-white-spaces-trial; *see also* Craig Wilson, *Inside SA's 'white spaces' broadband trial*, TechCentral (Jan. 10, 2013), https://www.techcentral.co.za/inside-sas-white-spaces-broadband-trial/37383/.

[xxv] Project Kgolagano, Worldwide Commercial Deployments, Pilots, and Trials, Dynamic Spectrum Alliance, http://dynamicspectrumalliance.org/pilots/#africa.

[xxvi] Press Release, Dynamic Spectrum Alliance, *Dynamic Spectrum Alliance Welcomes the Indian Government's Issuing of Eight Experimental Licenses in the 470-582 band for TV White Space Trials* (March 17, 2016), http://www.realwire.com/releases/Dynamic-Spectrum-Alliance-welcomes-the-Indian-Governments-issuing-of-eight

[xxvii] C. Mikeka, et al., *Malawi Television White Spaces (TVWS) Pilot Network Performance Analysis*, Journal of Wireless Networking and Communications, at 27 (2014); *see also Studies on the Use of Television White Spaces in South Africa*, at 30.

[xxviii] The Rhizomatica projects in Oaxaca, Mexico were awarded a social purpose license to operate their network because of its nature as an indigenous region.

[xxix] These are examples of innovative licenses in general, not necessarily related to community networks. However, policy makers can ensure that community networks have access to spectrum through innovative licensing.

[xxx] Press Release, Dynamic Spectrum Alliance (citation omitted).

[xxxi] Steve Song, *How to Let GSM Serve the People that Other Networks Can't Reach*, Many Possibilities, (Apr. 17, 2015), https://manypossibilities.net/2015/04/how-to-let-gsm-serve-the-people-that-other-networks-cant-reach/; Leandro Navarro, et al., *Advances in Wireless Community Networks with Community-Lab Testbed*, at 2; What We Do, Rhizomatica, https://www.rhizomatica.org/what-we-do/.

[xxxii] Steve Song, *How to Let GSM Serve the People that Other Networks Can't Reach*.

[xxxiii] For example, the IGF Dynamic Coalition on Community Connectivity, which is DC-3, published a Declaration on Community Networks during the IGF 2016, Guadalajara, Mexico: https://pad.codigosur.org/GuadalajaraDeclaration

[xxxiv] For example, "[i]n Nigeria, WiFi is free for private use but a license is required for commercial use. Senegal similarly requires users to apply for a license for point-to-point WiFi links." Steve Song, *A Look at Spectrum in Four African Countries*, Many Possibilities (March 31, 2014), https://manypossibilities.net/2014/03/a-look-at-spectrum-in-four-african-countries/.

[xxxv] *5G Spectrum, GSMA, Public Policy Position*, GSMA, at 5 (Nov. 2016), http://www.gsma.com/spectrum/wp-content/uploads/2016/06/GSMA-5G-Spectrum-PPP.pdf.

[xxxvi] *New Approaches to Spectrum Management*, OECD Digital Economy Papers, No. 235, at 21, (2014), http://dx.doi.org/10.1787/5jz44fnq066c-en.

[xxxvii] Operators here means mobile, fixed, and other infrastructure and content operators.

[xxxviii] Hernan Galperin, Wireless Networks and Rural Development: Opportunities for Latin America, at 48,53.