Prefaces by Kathryn Brown and Jan Dröge

Luca Belli Editor

Community Networks: the Internet by the People, for the People

Official Outcome of the UN IGF Dynamic Coalition on Community Connectivity

FGV DIREITO RIO

Internet Society

Community Networks: the Internet by the People, for the People

Official Outcome of the UN IGF Dynamic Coalition on Community Connectivity

United Nations Internet Governance Forum
Geneva, December 2017

Edition produced by FGV Direito Rio
Praia de Botafogo, 190 | 13th floor
Rio de Janeiro | RJ | Brasil | Zip code: 22250-900
55 (21) 3799-5445
www.fgv.br/direitorio

Community Networks: the Internet by the People, for the People

Official Outcome of the UN IGF Dynamic Coalition on Community Connectivity

Edited by *Luca Belli*

Preface by *Kathryn Brown* and *Jan Dröge*

FGV Direito Rio Edition

Printed in Brazil

1st edition finalized in 2017, November

This book was approved by the Editorial Board of FGV Direito Rio, and is in the Legal Deposit Division of the National Library.

Coordination: Rodrigo Vianna, Sérgio França e Thaís Mesquita
Book cover: Andreza Moreira
Layout: Andreza Moreira
Reviewer: Luca Belli

Ficha catalográfica elaborada pela Biblioteca Mario Henrique Simonsen/FGV

Community networks: the Internet by the people, for the people. Official outcome of the UN IGF Dynamic Coalition on Community Connectivity / Edited by Luca Belli; preface by Kathryn Brown and Jan Dröge. – Rio de Janeiro : Escola de Direito do Rio de Janeiro da Fundação Getulio Vargas, 2017.

242 p.

Inclui bibliografia.
ISBN: 978-85-9597-010-6

1. Internet – Política governamental. 2. Redes de computadores – Aspectos sociais. 3. Telecomunicações. 4. Comunicação no desenvolvimento da comunidade. I. Belli, Luca. II. Escola de Direito do Rio de Janeiro da Fundação Getulio Vargas.

CDD – 384.3

The opinions expressed in this book are the responsibility of the authors.

The Dynamic Coalition on Community Connectivity (DC3) is a component of the United Nations Internet Governance Forum and this book is the official 2017 outcome of the DC3.

This volume is the result of the annual DC3 Call for Papers, which is open to all interested stakeholders. Submitted papers have been evaluated for their novelty and their academic rigor as well as for the impact that the initiatives described in the paper may have. All accepted submissions have been peer-reviewed.

For further information on DC3, see www.comconnectivity.org

Acknowledgements

This book reflects many of the ideas discussed by the members of the Dynamic Coalition on Community Connectivity (DC3) of the United Nations Internet Governance Forum, between 2016 and 2017. The editor would like to express gratitude to all the DC3 members for their precious inputs.

Furthermore, the editor would like to thank the *Fundação Getulio Vargas Law School,*[1] which has provided the support and guidance, stimulating this research effort.

Lastly, the Editor would like to express gratitude to the Internet Society for generously supporting the publication of this book.

1 FGV is a world-renowned institution of research and quality education. In 2016, FGV was deemed as one of the top 10 think tanks in the world, according to the *Global Go To Think Tanks Index 2016*, produced by the Pennsylvania University. The Index also ranked FGV as the most influential think tank in Latin America over the past eight years. For further information, see http://portal.fgv.br/

CONTENT

PREFACE

by *Kathryn Brown*

Putting People at the Heart of the Internet

For 25 years the Internet Society has been home to a global community of people who are driven by a common idea: that when people obtain access to the Internet, amazing things can happen. Through the Internet, we can do things like share ideas, build communities, make tools we have not even dreamed of, and deliver healthcare or help children stay in school.

There is no question that relationships between humans and technology increasingly defines the world around us and that for a large swath of the globe, the Internet has become core to how people interact socially, conduct business and organize politically. We believe that everyone, everywhere should have access to same opportunities that the global information network we know as the Internet brings.

In 2015 the world made an important promise to itself. The United Nations set out 17 Global Goals – the Sustainable Development Goals – aimed at achieving extraordinary things in the next 15 years, including fighting injustice and inequalities, ending climate change, beating discrimination, bringing in sustainable energy, and making sure no one goes hungry.

We are now into the second year of working to keep that global promise. It is an enormous task. Rough estimates say that we will need at least $1 trillion in additional annual investment in developing and emerging economies to achieve them, so it's not surprising that many wonder whether achieving these noble goals is even possible. The Internet Society says it is. We know and work with people empowered by the Internet every day who believe the same.

The Internet itself is an enabler for the Goals. We will be able to get there faster and in a way that lasts, if everyone can access the Internet and benefit from it. In fact, SDG 9 focuses on the important role infrastructure and connectivity plays in connecting the least connected places on the planet. Here is the good news: according to a UN report on SDG 9 – in 2016, 95% of the worlds' population and 85% of people in the least developed countries were covered by a mobile signal.

Therefore, while four billion of the world's seven billion citizens are not yet connected, we have a real and present opportunity to bring all our people into our shared emerging digital future.

People around the world are dedicating their professional lives to ensuring that people in the hard to reach places on the planet are connected.

One of the ways to deliver that access is through community networks. Community networks are a complimentary way - across various sectors, economies, and technologies – to provide connectivity. They offer a way for anyone, anywhere, to be able to connect to the Internet as long as they have the right tools, partnerships, and support.

By empowering people in underserved villages across the world to connect themselves and their communities – community networks provide access where traditional or commercial networks do not reach or serve, or to areas where it may not be economically viable to operate.

They offer a complementary alternative to traditional, commercial telecommunications networks

Community networks also are a way to develop future business by creating "digitally savvy" communities, hungry for more local content and additional services. These often are not super high-tech networks. They serve a local community-driven purpose to connect within and to connect from the village or community "out". They might be local open-source 2G solutions, or Wi-Fi mesh solutions using license-free spectrum. The aim is to build capacity for both the demand and the supply of digital tools.

The Internet Society currently is supporting over 20 projects using different technologies to fulfill community needs with our partners.

In Nepal, for instance, in partnership with the Nepal Wireless Project, 12 schools, 2 health centers and a community hospital are up and running. In Tilonia, India, we have seen the success of the Wireless for Communities (W4C) project with our partner the Digital Empowerment Foundation. In Tusheti, Georgia, we worked with the Georgian government and partners to link up 15 remote mountain villages to help shape future business development and to keep families in touch who are spread across Georgia and the world. In Latin America, we are supporting partners who are working hand-in-hand with governments to change policies to support community networks - through innovative licensing and access to spectrum. In Africa, we are working with partners to train experts to scale community networks and deploy networks in places like Kibera - an underserved community in Nairobi, Kenya. In North America, we are exploring the critical need to connect indigenous communities in Canada and the United States. And, at the global level, we support networks and partners who are part of the Internet Governance Forum's Dynamic Coalition for Community Connectivity (DC3) to scale work and shape global communities.

We need to put our minds and energies together to forge new partnerships, strengthen existing ones, and support every-day heroes around the world who are changing the way connectivity is deployed. We can all support community networks in our own way.

Our vision has been and continues to be that the Internet is for everyone. Together, let's shape tomorrow.

Kathryn Brown

President and Chief Executive Officer of the Internet Society

PREFACE

by *Jan Dröge*

The Importance of Community-led Networks in Europe

The European Union set ambitious targets of universal coverage for all citizens by 2020, at 30 Mbps. In 2016, a new communication "Towards a Gigabit Society" raised this target to 100 Mbps by 2025. So far, around 76% of EU citizens are covered by fast internet access. However, this number drops to around 40% for people living in rural areas.

In Europe, we principally see the emergence of community-led networks in these rural and remote areas, where low population density, limited incomes, and the landscape itself can be challenges to investment by telecom operators – the main payers deploying broadband services in Europe.

Although the EU offers a number of public investment programmes to support closing this urban-rural "digital divide", rural areas across Europe continue to be under-serviced.

In some of these areas, such as in Germany and the UK, community-led networks have risen to the challenge, drawing on community, private and public funding. These local successes are recognised at EU level, where their learnings and innovative approaches are reflected in the annual Broadband Awards – which have honoured several community driven initiatives over the past years – and disseminated through the European Broadband Competence Offices Network (BCO Network).

This BCO Network was launched in 2017 as a further EU support to closing the "digital divide", helping Member States to reach the EU connectivity targets, and as a tool in the realisation of the European Digital Single Market.

The Network is animated by a dedicated Support Facility that connects the national and regional authorities responsible for broadband investment in all Member States, offering training, tools, and advice on policy, good practices and innovative solutions, and funding opportunities. Designated by the Member States, these authorities are recognised Broadband Competence Offices whose role is to serve as a single point of contact at national and regional level to make information on regulations and financial programmes more accessible to broadband project promoters, including at community level.

Rural communities as any other community in Europe must participate in the knowledge economy in order to seize the opportunities of a digital society.

For this reason, this book and the work of the UN IGF Dynamic Coalition on Community Connectivity represent a very positive example of how crowdsourced efforts can positively contribute to the identification and sharing of knowledge and good practices, leading to a more connected and empowered society.

Jan Dröge,
Director of the EU Broadband Competence Offices Support Facility

About the Authors

Luca Belli, PhD is Senior Researcher at the Center for Technology and Society (CTS) of Fundação Getulio Vargas Law School, Rio de Janeiro, where he heads the Internet Governance Project. Luca is also associated researcher at the *Centre de Droit Public Comparé* of Paris 2 University. Before joining CTS, Luca worked as an agent for the Council of Europe Internet Governance Unit; served as a Network Neutrality Expert for the Council of Europe; and as a consultant for the Internet Society. Over the past decade, Luca has authored and/or edited more than 30 research outputs on topics such as Internet and human rights, net neutrality, connectivity models, data protection and Internet governance institutions. Luca's works have been used *i.a.* by the Council of Europe to elaborate the Recommendation on Network Neutrality; quoted by the Report on Freedom of Expression and the Internet of the OAS Special Rapporteur for Freedom of Expression; and featured in several media outlets, including Le Monde, The Hill, O Globo and La Stampa. Luca is former board member of the Alliance for Affordable Internet (A4AI) and currently is the co-chair of the UN IGF Dynamic Coalitions (DCs) on Community Connectivity, on Platform Responsibility and on Network Neutrality.

Kathryn Brown joined the Internet Society as President and Chief Executive Officer in January 2014. A veteran of Internet policy development and initiatives that have aided in the Internet's global expansion, Ms. Brown leads the Internet Society in its mission to keep the Internet open, thriving and benefitting all people throughout the world. Ms. Brown's career spans the public and private sector, including serving in the United States National Telecommunications Information Administration (NTIA) and the Federal Communications Commission (FCC), and leading policy and global corporate social responsibility initiatives for telecom provider Verizon. She received her J.D., summa cum laude, from Syracuse University College of Law and her B.A., magna cum laude, from Marist College. Ms. Brown has served on the advisory boards of the Public Interest Registry (.ORG), the mPowering

Development Initiative of the ITU, and the USC Annenberg Innovation Lab.

Jan Dröge is Director of the EU Broadband Competence Offices Support Facility. For over 20 years, Jan has built up extensive insights into EU funding processes and has helped many institutions and organisations in their funding strategies. He was team leader on the study "Leveraging EU Funds for ICT Investments" and worked on numerous studies for the European Commission and the European Parliament. In 2016 Jan, was involved in the pilot phase, preparing for the EU network of Broadband Competence Offices (BCOs) where he was tasked with assessing the support structures that promote broadband investments in Germany, notably with the use of Structural Funds. Since January 2017, Jan is the Director of the BCOs Support Facility. He has advised Regions, EU Institutions and private clients on structural fund investments for broadband, including EU State Aid issues. Prior to joining BCO-SF and the Schuman Associates EU Consultancy, Jan worked in the European Commission' Directorate General for Regional Policy.

Sarbani Banerjee Belur, PhD is the Senior Project Research Scientist at Gram Marg: Rural Broadband project at Indian Institute of Technology Bombay (IIT Bombay). Sarbani holds a PhD in Demography from the University of Groningen, The Netherlands. She has a Master of Arts Degree in Sociology from University of Hyderabad, Population Studies from International Institute for Population Sciences, (IIPS) Mumbai. She has taught courses in Sociology and Development as a guest lecturer at Indian Institute of Technology Bombay and Tata Institute of Social Sciences, Mumbai. She has published in international conferences, contributed book chapters in the area of demography and social issues. Her PhD titled 'Higher education and the reproductive life course: A cross-cultural study of women in Karnataka (India) and the Netherlands has been published as a book by the Dutch University Press. Her current work involves increasing digital outreach to remote, un-served rural areas of India, development and deployment of new technology alternatives for the middle and last mile internet connectivity and development of a sustainable economic model based on Public-Private-Panchayat Partnership (4-P model). She is working on Impact studies of Internet connectivity, gender gap in digital divide and cost effectiveness of technologies for rural broadband.

Peter Bloom holds a BA in Urban Studies from the University of Pennsylvania and a Master's degree in Rural Development from the Autonomous Metropolitan University in Xochimilco, Mexico. He is the founder (in 2002) and ex-director of Juntos, the first organisation in Philadelphia dedicated to organising and defending the human rights of Latino immigrants. In 2009, Peter began working in Nigeria as a development consultant and media maker and lived in the Niger Delta region of Nigeria for two years, co-founding the Media for Justice Project based outside of Port Harcourt. Since 2009 Peter has been coordinating Rhizomatica, an organisation he started to promote new communication technologies and that helped start the first community-owned and managed cell phone network in the Americas in 2013. Peter is both an Ashoka and Shuttleworth Foundation fellow since 2014. For his work on telecommunications and community development, in 2015 he was named an MIT Technology Review Innovator Under 35 and one of the *Foreign Policy* 100 Leading Global Thinkers.

Anriette Esterhuysen is the global advocacy policy strategy director for the Association for Progressive Communications (APC), an international network of organisations working with Information and Communications Technologies (ICT) to support social justice and development. Prior to joining APC Esterhuysen was executive director of South African APC member SANGONeT, an Internet service provider and training institution for civil society, labour and community organisations. From 1987 to 1992, when she joined SANGONeT, she did information and communication work in development and human rights organisations in South Africa and Zimbabwe. While she was at SANGONeT, Esterhuysen, with many others, helped establish email and Internet connectivity in

Southern Africa. She has served on the African Technical Advisory Committee of the UN's Economic Commission for Africa's African Information Society Initiative and was a member of the United Nations ICT Task Force from 2002 to 2005, the World Summit on the Information Society (WSIS) Task Working Group on Financing Mechanisms, and the Commission for Science and Technology for Development Working Group on Internet Governance Forum (IGF) Improvements. She is currently a member of the Multistakeholder Advisory Group of the Internet Governance Forum and serves on the boards of Global e-Schools and Communities Initiative and Ungana-Afrika. Esterhuysen has published extensively on ICTs for development and social justice.

Nathalia Foditsch (LLM/MPP) is a Washington D.C. based licensed attorney specialised in communications policy and regulation. She has worked for different think tanks, international organisations and for the Brazilian Federal Government. Among her publications is a book she has co-edited and co-authored called "Broadband in Brazil: Past, Present, Future" (Novo Século / Google), which was published in 2016 in English and Portuguese.

Maureen Hernández is a system engineer, graduated from the University of Los Andes (ULA), Venezuela. Maureen has been formed on CISCO CCNA, School on applications of Open Spectrum and White Spaces technologies at Abdus Salam ICTP, Wireless Networks for Data Transmissions WIFI & WiMAX at WALC, Microsoft Professional Program for Data Science, and Sensor Networks at WALC. She has been elected as part of the board of directors of the Venezuelan chapter for the ongoing cycle and to participate as a fellow on the committee designated to attend to the World Telecommunication Development Conference (WTDC-17) in Buenos Aires this year. In addition, she has been a fellow for ISOC programs like IGF ambassadors, IETF fellows, Southern School on Internet Governance and ISOC Next Generation Leaders. Currently, she is working on a holistic model proposal for Community Networks deployment and maintenance while working with rural communities in Latin America and with the LAC ISOC Chapters building a summarisation of community networks in the region.

Erick Huerta, is PhD candidate in Rural Development from UAM Xochimilco and holds a Master's Degree in Social Administration with a speciality in Community Development from Queensland University. He holds a law degree from Universidad Iberoamericana and post-grad from Escuela Libre de Derecho. Erick is an Expert of the International Telecommunication Union for connectivity issues related to remote areas and indigenous peoples and he has served as Coordinator of the Study Group on Development, at the Permanent Consultative Committee 1 of the Inter-American Telecommunication Commission of the OAS (2010-2014). He was member of the advisory council of IFETEL, the Mexican telecommunications regulator from (2015-2017). He designed the legal strategy of the first Mobile Indigenous Community Telephony in the world. He is the General Coordinator of *Redes por la Diversidad, Equidad y Sustentabilidad* A.C., association that has accompanied diverse organisations such as the National Congress of Indigenous Communication in Mexico.

Mike Jensen is advisor on internet access, telecommunications infrastructure and ICT policy. He is a South African based in Brazil and Portugal who has worked on ICT infrastructure projects in over 45 developing countries since 1989. Mike co-founded an internet provider for NGOs in 1986, which became one of the founding members of APC (The Web – web.net). He recently managed a global project for APC to promote infrastructure sharing policies and regulations in developing countries. He is currently advising ECOWAS on its regional ICT infrastructure development plans and he helped devise a similar Regional Infrastructure Development Master Plan (RIDMP) for Southern Africa. He has also assisted in strategy development for USAID backbone connectivity support for the Post Ebola Crisis countries while advising the World Bank on ICT broadband policy and infrastructure gaps in West Africa.

Meghna Khaturia is currently an MTech + PhD student in the Department of Electrical Engineering at the Indian Institute of

Technology Bombay. She received her Bachelor's in technology from Sardar Vallabhbhai National Institute of Technology, Surat, in 2013. Her research interests are cost-effective technology and network design for rural broadband, TV White Spaces and spectrum sharing in wireless networks.

Michael J. Oghia is a Belgrade, Serbia-based independent consultant and editor working with several Internet governance topics, specifically focusing on sustainable access, digital rights, media literacy, and capacity building. He has professional experience in conflict resolution, journalism and media, civil society, and academia across five countries: the United States, Lebanon, India, Turkey, and Serbia. Michael has been a two-time ISOC ambassador to the Internet Governance Forum (IGF). He frequently writes about development and the relationship between the Internet and sustainability. Michael holds a Master of Arts in sociology from the American University of Beirut.

Nanditha Rao, PhD received her PhD in Electrical engineering in 2017 from Indian Institute of technology Bombay. She worked at Intel Technologies in Bangalore from 2004 to 2010 as a hardware design engineer. Her research interests include technology for rural areas, biosensors and computer architecture.

Carlos Rey-Moreno, PhD received a telecommunications engineering degree at the Carlos III University of Madrid (UC3M, Spain), a Masters Degree in Development and International Relations at Aalborg University (AAU, Denmark), and a Masters Degree and PhD in Telecommunications Networks for Developing Countries at Rey Juan Carlos University (URJC, Spain) in 2006, 2008, 2010 and 2015, respectively. In 2007-2011, he was a researcher at the EHAS Foundation working on rural broadband telemedicine networks in Spain, Peru and Malawi. In 2012, he moved to South Africa and joined the University of the Western Cape to lead the work on rural telephony networks. As a result, he has spent over three years living in rural South Africa, understanding their communication usage and expenditure patterns and proposing solutions to provide more affordable and universal access. One of the main outcomes of his work was the co-creation of Zenzeleni Networks with the community of Mankosi, a community-owned ISP providing affordable communications in rural Eastern Cape, South Africa. In studying how to scale Zenzeleni Networks, he has become one of the most knowledgeable people about the community networks movement in Africa by co-organising the two Summits of Community Networks in Africa, and authoring an in-depth report on the topic.

Steve Song is a researcher and consultant working to expand the use of wireless technologies through shared spectrum strategies and to enable greater internet access throughout Africa and other emerging markets. He is also the founder of Village Telco, a social enterprise that builds inexpensive WiFi mesh VoIP technologies to deliver affordable voice and internet options in underserved regions. Steve is a regulator commentator on African telecommunications issues at ManyPossibilities.Net. He has been involved in advocacy for dynamic spectrum regulation related to television broadcast spectrum since 2008 and was instrumental in the launch of the first Television White Space pilot in South Africa in 2011.

Since 2009, Steve has been actively maintaining public maps of undersea and terrestrial fibre optic infrastructure in Africa as well as information on wireless spectrum frequency assignment and occupancy in African countries. From 1997 to 2007, he worked at the International Development Resource Centre, where he led the organisation's Information and Communication Technology (ICT) for Development programme in Africa and funded research into the transformational potential of ICTs across the continent.

Ritu Srivastava has over 10 years of rich professional experience in ICT development, managing programmes and projects at different stake-levels of competency. She has been advocating for and managing the development of Information, Communication and Technology (ICT) over the last 8 years. Her area of interest, activity and research is in Information Communication and Technology (ICT) at the grassroots level, internet governance, environmental issues, community development, gender & access, open spectrum policy issues, internet governance, etc. Presently, she is assisting Delhi based non-profit organisation, Digital Empowerment Foundation (DEF) in various ICTD related projects and responsible for project design, ideation, implementation, leading policy meetings, fun-raising proposals, partnership forging, event guidance, workshops management and organising. She also represented DEF in various international conferences.

Bruno Vianna holds a degree in film studies from the Federal University in Rio de Janeiro, and graduated at New York University's Interactive Telecommunications Program. His short, feature and interactive film projects won several awards. Currently, he runs Nuvem, a rural citizen science space and hacklab, and teaches at Oi Kabum!, an art and technology school based in Rio de Janeiro. He is a co-founder of Coolab, a cooperative dedicated to fostering community telecommunications.

1 Introducing the Evolving Community Network Debate

Luca Belli

This book is the Official 2017 Outcome of the UN IGF Dynamic Coalition on Community Connectivity (DC3).[1] The UN IGF is a global multistakeholder platform that facilitates the discussion of public policy issues pertaining to the Internet. DC3 is a multistakeholder group[2] aimed at fostering a cooperative analysis of the community network model, exploring how community networks (CNs) may be used to foster the sustainable expansion of Internet connectivity while empowering Internet users. DC3 provides a shared platform involving all interested individuals and institutions into a multistakeholder analysis of community connectivity issues. This book should be seen as a further step towards a better understanding of community networking and is built upon the previous efforts of the DC3.[3]

This volume is structured in two sections exploring benefits, challenges and opportunities for CNs and analysing a series of CN case studies and forward-looking proposals, from which useful recommendations can be drawn. As a conclusion, this book includes the updated version of the **Declaration on Community Connectivity**, which was elaborated through a multistakeholder participatory process, featuring an online open consultation, between July and November 2016, a public debate and a feedback-collection process, during the IGF 2016, and a further online consultation, between December 2016 and March 2017.

As stated by the Declaration on Community Connectivity, CNs are crowdsourced networks

1 For further information, see www.comconnectivity.org

2 Dynamic Coalitions are components of the United Nations Internet Governance Forum. Coalitions are informal, issue-specific groups comprising members of various stakeholder groups. For further information, see https://www.intgovforum.org/multilingual/content/dynamic-coalitions-4

3 See http://www.intgovforum.org/multilingual/content/dynamic-coalition-on-community-connectivity-0?qt-dynamic_coalition_on_community_c=4#qt-dynamic_coalition_on_community_c

> "structured to be open, free, and to respect network neutrality. Such networks rely on the active participation of local communities in the design, development, deployment, and management of shared infrastructure as a common resource, owned by the community, and operated in a democratic fashion. Community networks can be operationalised, wholly or partly, through individuals and local stakeholders, NGO's, private sector entities, and/or public administrations."

For this reason, it can be argued that CNs promote a community-centred Internet, developed for the people, by the people. Building on the previous works of the DC3, this book aims at fostering a better understanding of what CNs are and the opportunities that these initiatives offer to promote a sustainable Internet environment, fostering a sustainable connectivity agenda and allowing the greatest possible number of individuals to enjoy the benefits of information and telecommunications technologies.

1.1 Benefits, Challenges and Opportunities for Community Networks

The first part of this volume explores a variety of regulatory, technical, social and economic challenges raised by community-networking initiatives. The five chapters included in this part do not simply analyse the challenges faced by CNs but put forward potential solutions, suggestions and recommendations that are based on critical observation and evidence-based analyses of CNs and should be considered by all stakeholders.

In the opening chapter on "**Network Self-Determination and the Positive Externalities of Community Networks**," Luca Belli argues that existing examples of CNs provide a solid evidence-base on which a **right to network self-determination** can be constructed. Network self-determination should be seen as the right to freely associate in order to define, in a democratic fashion, the design, development and management of network infrastructure as a common good, so that all individuals can freely seek, impart and receive information and innovation. First, this chapter argues that the right to network self-determination finds its basis in the fundamental right to self-determination of people as well as in the right to informational self-determination that, since the 1980s, has been consecrated as an expression of the right to free development of the personality. In this sense, the author emphasises that, network self-determination plays a pivotal role allowing individuals to associate and join efforts to bridge digital divides in a bottom-up fashion, freely developing common infrastructure.

Subsequently, Belli examines a selection of CNs, highlighting the **positive externalities** triggered by such initiatives, with regard to the establishment of new governance structures as well as the development of new content, applications and services that cater for the needs of the local communities, empowering previously unconnected individuals. The chapter offers evidence that the development of CNs can prompt several positive external-effects that considerably enhance the standards of living of the CN members, creating learning opportunities, stimulating local entrepreneurship, fostering the creation of entirely new jobs, reviving social bounds amongst community members and fostering multistakeholder partnerships. For these reasons, policymakers should design national and international **policy frameworks** that recognise the importance of network self-determination and facilitate the establishment of CNs rather than hindering their development.

In his chapter on "**Barriers for Development and Scale of Community Networks in Africa**," Carlos Rey-Moreno explains that that CNs should be seen as communications infrastructure deployed and operated by citizens to meet their own communication needs and such initiatives are being increasingly proposed as a solution to foster connectivity. However, the author emphasises that, in Africa, where the proportion of unconnected individuals is among the highest globally, the number of initiatives identified is relatively low considering the continent's size and population. Hence, the chapter focuses on **the barriers** that prevent more CNs from appearing or existing ones from becoming sustainable and scaling. The barriers identified range from the lack of awareness of both the potential benefits of accessing information, and the Internet more generally, and the possibility for communities to create their own network, to the lack of income of the people who would like to start one.

Importantly, Rey-Moreno notes that most of the people within the next billion to be connected **need to choose**, daily, between Internet/communication networks and other vital necessities such a food and health. The unreliable (or the complete lack of) electricity in most of these areas, and the prohibitive cost of backhaul connectivity, also affects the capital required to start and operate CNs. The lack of local technical competencies, and a regulatory framework not conducive for the establishment of small, local communication providers, are also identified as the main barriers for growth of community networks in the region. Despite this breadth of barriers, African communities are proving that some, if not all, of these barriers have been addressed. As stressed by Rey-Moreno, this is motivating global organisations to contribute creating an **enabling environment** that removes these barriers.

In his chapter on "**Community Networks as a Key Enabler of Sustainable Access**," Michael J. Oghia defines sustainable access to the Internet, as the ability for any user to connect to the Internet and then stay connected over time, thus contributing critically to **sustainable development**. The author argues that CNs are ideal to catalyse sustainable access, but the challenge of generating **reliable energy** to power infrastructure continues to pose a significant barrier to lowering costs and the ability to scale. This chapter aims to highlight the link between community networks and the broader agenda on sustainability, defines sustainable access, and explores the connection between infrastructure, energy, and Internet access, while concluding by outlining the role of CNs as a pillar of enabling sustainable access.

In their paper on "**Can the Unconnected Connect Themselves? Towards an Action Research Agenda for Local Access Networks**," Carlos Rey-Moreno, Anriette Esterhuysen, Mike Jensen, Peter

Bloom, Erick Huerta and Steve Song argue that community-based solutions to building local network infrastructure are increasingly being considered as viable alternatives to traditional large-scale national deployment models. Use of low-cost networking equipment to provide communication infrastructure built in a bottom-up manner is growing, especially in **rural areas** where connectivity is poor. While there are instances of these solutions that stand as real-world examples of ways to improve access to ICTs and provide affordable and equitable access, these models of Internet access provision are still not widely known or well accepted, usually being deemed as 'fringe' solutions to connectivity needs that lack widespread applicability or the potential to scale. This chapter outlines a **proposed action research agenda** and methodology for providing an evidence-based understanding of the potential role of these types of local infrastructure solutions in meeting the needs of the unconnected, as well as those on costly-metered broadband services.

Erick Huerta, Peter Bloom and Karla Velasco's chapter on "**The Success of Community Mobile Telephony in Mexico and its Plausibility as an Alternative to Connect the Next Billion**" closes the first part of this volume. The authors introduce a framework for the design and instrumentation of Community Mobile Telephony (CMT) from a Mexican perspective but applicable to other regions. Particularly, this chapter describes the case of *Telecomunicaciones Indigenas Comunitarias A.C*. and **Rhizomatica** whose CMT began operating in 2013 in Talea de Castro, Oaxaca, under a private network scheme and using a segment of spectrum, acquired for free-and-non-profit use. The case analysed in this chapter demonstrates that, under a new technical, economic and organisational scheme, it was possible to offer, in a sustainable manner, mobile services in commercially unfeasible localities. After 3 years, since inception, the system covered eighteen localities of between two hundred and three thousand habitants. As Huerta and Velasco emphasise, these data confirm not only the viability of the model but also the possibility to expand it to communities without **mobile service**. Moreover, this experience paved the way for the creation of a new framework among traditional operators, which allowed them to connect rural locations, previously deemed inviable. Importantly, the success of the project has given way to a **new legal framework** and a modification in spectrum administration, which, for the first time in Mexican history, assigned a portion of GSM spectrum for social purposes. The success of the Mexican case proves that Community Mobile Telephony is **a plausible option** that should be embraced to connect over 2 billion people without affordable mobile coverage and the 700 million with no coverage at all, by supporting communities to build and maintain self-governed and owned communication infrastructure.

1.2 Case Studies: Building Connectivity in a Bottom-up Fashion

The second part of this work analyses a selection of CNs, stressing the diversity of the social, economic and technical backgrounds from which CNs may originate as well as highlighting the existence of very heterogeneous models that may be utilised to establish and maintain CNs. The cases presented in this section witness the variety of CNs and demonstrate that these initiatives may be developed in many different environments. While very useful teachings can be drawn from these experiences, it seems clear that further research on the matter can be very beneficial and should be incentivised.

Ritu Srivastava opens the second part with her chapter on "**Policy Gaps and Regulatory Issues in the Indian Experience on Community Networks,**" discussing the Digital Empowerment Foundation's Wireless for Communities model, exploring the legal and regulatory challenges frequently faced by CNs in developing countries, with particular regard to spectrum allocation and management, licensing regulation, and bandwidth policies in India. The author maps out the common elements of these **challenges** among CNs and, subsequently, addresses policy and regulatory issues. Notably this chapter investigates the efficacy of creating Wireless Community Networks, Rural Internet Service Providers or community-based Internet Service Providers and explores the possibility of policies, which could help in creating widespread information infrastructure for developing countries, with a focus on India, in order to better connect the subcontinent. Importantly, Srivastava's paper puts forward a number of **recommendations for policy-makers**, regulatory bodies, and related stakeholders. Such recommendations are organised into national recommendations and regional and international recommendations. The national recommendations include suggestions regarding how to alleviate unnecessary regulatory and fiscal hurdles on small/rural Internet Service Providers and CNs in India. The regional and international recommendations focus on creating a more enabling policy and regulatory environment for CNs, in general, and can be applied to any national context.

In their chapter on "**Community-led Networks for Sustainable Rural Broadband in India: the Case of Gram Marg**," Sarbani Banerjee Belur, Meghna Khaturia and Nanditha P. Rao argue that, to bridge the digital divide facing rural India, a cost-effective technology solution and a sustainable economic model based on community-led networks is needed. **Gram Marg Rural Broadband** project at IIT Bombay, India has been working on both these aspects through field trials and test-bed deployments. The authors critically argue that, even if the connectivity reaches rural India, the network infrastructure would not be able to sustain itself at the village level, without a **sustainable economic model**. This chapter analyses the findings of the impact studies performed by the authors, which have exposed the need for community owned networks. Conspicuously, the study reveals that villagers have a clear understanding that they can save time and money, when Internet connectivity reaches the village. However, the adoption of traditional Internet access provision paradigm was not sustainable.

On the contrary, villagers suggested community-led networks would enable them to "own Internet" and, to this end, the **Public-Private-Panchayat Partnership** (4-P) model was developed. In this context, the Panchayat, which is the local self-government – which operates at the village level according to the Indian decentralised administration system – takes **ownership of the network**. The partnership enables the network to be community-led for effective decision making and prioritising services based on the needs of the villagers. The public-private partnership enables Internet connectivity to reach the village from where the management is taken over by the Panchayat that supports the investment for the local network infrastructure, at the village level. Local youth known as **Village Level Entrepreneurs** (VLEs) invest, maintain the network and generate revenue. The authors stress that the model ensures a decent and sustainable **return on investment** for the Panchayat and defines a nominal user subscription cost. It also considers expected future growth in demand and related cost dynamics. This chapter offers a crucial perspective on the relevance of revenue generation and sharing, stressing that CNs can be economically sustainable, providing incentive for connectivity expansion and empowerment of local villagers.

In his chapter on "**Comparing Two Community Network Experiences in Brazil**," Bruno Vianna describes two installations of community networks in two different environments in the state of Rio de Janeiro, Brazil. The first case study, completed in 2015, was established in the **rural village** of Fumaça. The development of this CN was made possible thanks to a grant from Commotion Wireless and was built by a team of volunteers together with the members of the local community. To date, the network remains operational, providing free and open access to the Fumaça community. The second one was established in the Maré Complex, an area concentrating a considerable number of **favelas** in the city of Rio de Janeiro. It was made possible through an open call for workshops from the Rio de Janeiro state government, and was implemented by the students who participated in the weeklong course and were, for the main part, coming from the local favelas. The two cases provide interesting information regarding the potential for CNs in the global south, highlighting the possibility that such initiative can have with regard to **capacity-building**, **empowerment** and the creation of new opportunities for **youngsters**.

In her chapter on "**Beyond the Invisible Hand: the Need to Foster an Ecosystem Allowing for Community Networks in Brazil**," Nathalia Foditsch provides a useful complement to the discussion started in the previous chapter by Bruno Vianna, arguing that the debate over CNs is not new in Brazil but needs to gain momentum again, in order to overcome some obstacles. Notably, the author emphasises that promoting a **favourable ecosystem** is a challenge that goes beyond the technical aspects of deploying and managing such networks. Recent advancements show signs of an increasingly encouraging environment for CNs, but a lot remains to be done. This chapter briefly discusses some **challenges** and new **regulatory developments** in Brazil and explores how the work of the IGF Dynamic Coalition on Community Connectivity might contribute to the promotion of an ecosystem that facilitates the establishment of CNs.

In her chapter on "*Diseño e Implementación de una Aplicación Web para la Visualización Mundial de Despliegues de Redes Comunitarias*" (**Design and Implementation of a Web Application for the Global Visualisation of Community Network Deployments**), Maureen Hernandez stresses that it is currently hard to obtain systematised information regarding the existing CN deployments around the world. Nothing the lack of a database or repository providing basic **information about CNs**, such as the name, localisation, and contact person of these initiatives, the author proposes to remedy to this lacuna though the development of technical tool. This chapter proposes to collect data on CNs to organise them to facilitate interactions among stakeholders and take advantage of the lessons learned, instead of letting each community starting from zero. Hernandez argues that such effort may be feasible based on the outcomes that have been developed, to date, by initiatives like the UN IGF Dynamic Coalition for Community Connectivity or the research group Global Access to the Internet for All (GAIA), from the Internet Research Task Force (ITRF). The paper argues that the ability to **visualise** information about CNs into a unique tool may be a crucial factor not only to promote and inspire more deployments but also to understand how far these initiatives have come and how different their characteristics may be. In this perspective, the proposed “**Community Connectivity Map**” aims at including data about the largest possible number of CNs on a map, allowing stakeholders themselves to add data to be validated manually.

PART I

Benefits, Challenges and Opportunities for Community Networks

2 Network Self-Determination and the Positive Externalities of Community Networks

Luca Belli

Abstract

This paper argues that existing examples of Community Networks (CNs) provide a solid evidence-base on which a right to "network self-determination" can be constructed. Network self-determination should be seen as the right to freely associate in order to define, in a democratic fashion, the design, development and management of network infrastructure as a common good, so that all individuals can freely seek, impart and receive information and innovation.

The first section of this paper argues that the right to network self-determination finds its basis in the fundamental right to self-determination of peoples as well as in the right to "informational self-determination" that, since the 1980s, has been consecrated as an expression of the right to free development of the personality. The paper emphasises that, network self-determination plays a pivotal role allowing individuals to associate and join efforts to bridge digital divides in a bottom-up fashion, freely developing common infrastructure. In this perspective, the second section of this paper examines a selection of CNs, highlighting the positive externalities triggered by such initiatives, with regard to the establishment of new governance structures as well as the development of new content, applications and services that cater for the needs of the local communities, empowering previously unconnected individuals.

The paper offers evidence that the development of CNs can prompt several positive external-effects that considerably enhance the standards of living of individuals, creating learning opportunities, stimulating local entrepreneurship, fostering the creation of entirely new jobs, reviving social bounds amongst community members and fostering multistakeholder partnerships. For these reasons, policymakers should design national and international policy frameworks that recognise the importance of network self-determination and facilitate the establishment of CNs rather than hindering their development.

2.1 Introduction: Network Self-Determination as a Bottom-up Answer to Market Failures

Community Networks (CNs) are crowdsourced networks developed in a bottom-up fashion to be utilised and managed as a common good. As stressed by the Declaration on Community Connectivity CNs are "structured to be open, free, and to respect network neutrality. Such networks rely on the active participation of local communities in the design, development, deployment, and management of shared infrastructure as a common resource, owned by the community, and operated in a democratic fashion."[4] Importantly, these community-driven networks give rise not only to new infrastructure but also to new governance models and new business opportunities that complement and fill the gaps left by the classic Internet access provision paradigm.[5] Indeed, this traditional paradigm, where mainstream-network operators deploy infrastructure in a top-down fashion, presents some clear limitations that are tellingly exemplified by the almost-4-billion individuals[6] that still lack Internet connectivity, to date. Therefore, the emergence of CNs represents a direct reaction from the populations that are closely interested by the wide range of existing digital divides and do not want to give up what this paper defines as "right to network self-determination."

The thesis of this paper is that groups of individuals experiencing digital divides, as well as any other community, have a right to free development of network infrastructure and that "network self-determination" is an instrumental condition to allow the full exercise of individuals' human rights. Such network self-determination can be enjoyed when individuals can freely associate in order to define, in a democratic fashion, the design, development and management

4 See Declaration on Community Connectivity, at p. 236 of this book. The Declaration is also available at https://comconnectivity.org/article/dc3-working-definitions-and-principles/

5 In this paper, the expression "traditional Internet access provision paradigm" refers to the Internet access model based on the existence of a mainstream-network operator and a plurality of subscribers. As clarified by RFC 7962, the expression "mainstream network" denotes those networks that are usually large and span wide areas; are controlled in a top-down fashion by the operator; require a substantial investment to be built and maintained; and do not allow user participation in the network design, deployment, operation, governance, and maintenance. See (Saldana *et al.* 2016).

6 For a precise estimation, compare the number of world Internet users and the current world population at http://www.internetlivestats.com/internet-users/ and http://www.worldometers.info/world-population/

of network infrastructure as a common good, so that they can freely seek, impart and receive information and innovation.

The first section of this paper will argue that the right to network self-determination finds its basis in the fundamental right to self-determination of peoples[7] as well as in the right to "informational self-determination"[8] that, since the 1980s, has been consecrated as an expression of the right to free development of the personality. This paper will emphasise that network self-determination plays a pivotal role allowing individuals to associate in collective entities, joining efforts to bridge digital divides in a participatory and bottom-up fashion. In this perspective, the second section of this paper will examine a selection of CNs, highlighting the positive externalities triggered by such initiatives, with regard to the establishment of new governance structures as well as the development of new content, applications and services that cater the needs of the local communities, empowering previously unconnected individuals.

CNs are a prime example of how individuals can enjoy the right to network self-determination. However, before analysing the conceptual bases of this right and entering the CN debate, it is important to stress that the populations affected by digital divides – which have a concrete interest in exercising network self-determination establishing CNs – may have quite diverse profiles. In fact, although digital dividends are particularly noticeable between urban and rural populations, they may also affect individuals residing in different areas of the same city, where inhabitants enjoy dissimilar standards of living.[9] In many countryside areas and in the peripheries and slums[10] of many metropoles, the population is scarce

7 This fundamental right is prominently enshrined in Article 1 of the Charter of the United Nations as well as in Article 1 of both the International Covenant on Economic, Social and Cultural Rights, the International Covenant on Civil and Political Rights.

8 See the seminal "Census" decision of the German Constitutional Court. Judgment of 15 December 1983, BVerfGE 65, 1-71, Volkszählung.

9 For an analysis of existing digital dividends, see World Bank (2016); ITU (2016a).

10 UN-HABITAT defines slums as "urban areas lacking (i) durable housing of a permanent nature that protects against extreme climate conditions; (ii) sufficient living space which means not more than three people sharing the same room; (iii) easy access to safe water in sufficient amounts at an affordable price; (iv) access to adequate sanitation in the form of a private or public toilet shared by a reasonable number of people; (v) or security of tenure that prevents forced evictions." See http://mirror.unhabitat.org/documents/media_centre/sowcr2006/SOWCR%205.pdf

and individuals may enjoy significantly lower standards of living and, for these reasons, operators neglect the expansion of network infrastructure, due to the insufficient return on investment. Hence, the "traditional" model of Internet access provision, which is driven by investments of telecom operators, should not be considered as a one-size-fit-all solution because, although it may prove efficient to cater connectivity to urban and wealthy populations, it clearly needs to be complemented with different approaches to meet the needs of a more diversified – and less wealthy – public. Notably, the market approach may face two types of failure in both rural and peripheral areas:

- the prospect of a missed return on investment may lead to no coverage or to such low quality of service that potential or existing users may be discouraged from subscribing to available Internet-access offerings;
- due to lack of competition, Internet-access offerings may be prohibitively expensive for most of the economic deprived areas, where inhabitants may need to sacrifice food to afford communication.[11]

Besides the aforementioned elements, many individuals may not realise the interest of Internet connectivity because the services and content they would need, such as local e-government services, local e-commerce, e-health and local content tailored on the linguistic exigencies of the local population, are not available online.

The emergence of CNs is therefore a concrete response to these situations, with the aim of truly empowering the unconnected, allowing individuals and communities to enjoy network self-determination, having access to all the opportunities that connectivity can provide, while becoming able to generate even more opportunities. As the second section of this paper will argue, the analysis of existing community-networking initiatives provides a solid factual base for the promotion of a collective right to network self-determination, which can be enjoyed through the establishment of community-led networks. Indeed, CNs have the

11 See Rey-Moreno *et al*. (2016).

potential to allow the creation of new socio-economic opportunities for the local communities that engage in the development of the networks, truly participating to the evolution of the Internet.

2.2 The Right to Network Self-Determination

It is important to reiterate that one of the primary features of CNs is to be tailored on the needs of the communities at the origin of such initiatives. This consideration is particularly relevant, if we think about connectivity in terms of self-determination and if we consider CNs as the reflex of local communities' needs and will. The ultimate goal of CNs is to respond to the necessities of the communities who builds them and, in this perspective, the prominence of the community interest is so relevant that CN-members may decide not to be connected to the Internet but rather to build local intranets or to connect the CN to the Internet only sporadically.[12] In some other cases, the community members may even decide to structure the CNs as radio-based networks, like the Fonias Juruá network[13] in the Brazilian Amazon, rather than IP based networks.

The following subsection will argue that the right to develop network infrastructure stems from the fundamental rights to self-determination of peoples as well as to enjoy the benefits of scientific progress and its applications.

2.2.1 The Fundamental Right to Self-Determination of Peoples as a Foundation of Network Self-Determination

The fundamental right to self-determination plays an instrumental role allowing individuals to enjoy all their inalienable human rights and, for this reason, it is enshrined as the first article of both the Charter of the United Nations and the International Covenants of Human Rights. According to these international-law instruments, states have agreed that "all peoples have a right to self-determination" and that "by virtue of that right they are free to determine their political status and to pursue their economic,

12 The description of a selection of CNs which have opted to primarily work as intranet and connect only occasionally to the Internet can be found in Rey-Moreno (2017).

13 See Antunes Caminati *et al.* (2016).

social and cultural development."[14] Furthermore, Article 55 of the UN Charter corroborates the aforementioned provisions enjoining UN member states to generate stability and well-being "based on respect for the principle of equal rights and self-determination of peoples" while both Articles 1(3) of the Covenants oblige the signatories "to promote the realisation of the right to self-determination." Although such provisions have been interpreted, in a post-colonial context, as the right to territorial secession of each ethnic, linguistic or religious group, this is not the interpretation based on which this paper proposes to construct the right to network self-determination. On the contrary, this section argues that network self-determination should be associated to the interpretation of the right to self-determination as the collective right of a community to determine its own destiny, promoting socio-economic development and self-organisation.

I should reiterate that network self-determination shall not be associated with territorial separation, but rather to the essence of the right to self-determination as the right of choice and a right of process belonging to peoples, which is formally recognised through binding international-law instruments. When it comes to connectivity, this means, first, having the possibility to choose to design and organise in an independent and democratic fashion the shared network infrastructure that will allow individuals to interconnect and, second, having the possibility to implement such choice. In this perspective, we should look at CNs not only as a concrete strategy to expand connectivity but also as a laboratory for new governance structures allowing the transposition of the democratic organisations of local communities into the governance of the electronic networks that provide connectivity to such communities. For these reasons, public policies should facilitate and promote the establishment of CNs.

It is important to stress that network self-determination allows building a direct bridge between human rights and connectivity. Connectivity is instrumental to allow individuals to fully enjoy freedom of expression and, in the Internet environment, this

14 For a thorough overview of the right to self-determination, see Cristescu (1981).

fundamental right to seek, impart and receive information and ideas should be seen as every individual's right to access, develop and share content, applications and services, without interference. Importantly, it should also be stressed that the right to communicate should be considered as a right rather than an obligation to connect with the rest of the world permanently or to use a specific type of technology or applications, imposed by an "external intervention." As such, individuals should be able to self-determine how they wish to organise the network infrastructure allowing them to improve their political, economic and social status and independently decide which kind of technology, applications and content are best suited to meet the needs of their local community. Therefore, network self-determination should be considered in terms of cultural, economic and technological autonomy, which is essential to further human rights and dignity of every individual and group of individuals.

In this perspective, policymakers should consider these latter points carefully, when deliberating on how Universal Access Funds should be utilised. Indeed, these funds could have a significant impact if they were utilised – at least in part – to support the establishment of community networking initiatives, thus providing concrete opportunities for individual empowerment, rather than being used for inefficient subsidies or even for "unknown"[15] purposes. National governments should try to devote at least a fraction of the financial resources collected through Universal Access Funds to programmes providing seed funding to the organisations or individuals that propose solid plans for the development of CNs, which offer a wide range of positive externalities, as I will stress in section 2.3. The next subsection will explore the second conceptual basis of network self-determination that can be found into "informational self-determination", a fundamental right that was first and foremost elucidated by the German Constitutional Court.

15 In Brazil, for instance, Universal Access Funds collected between 2001 and 2016 amounted to roughly $ 7billion but, according to the Brazilian Federal Court of Auditors, only 1% was utilised for universalisation programmes while 79% was utilised for "unknown" purposes. See http://convergecom.com.br/wp-content/uploads/2017/04/Auditoria_TCU_fundos.pdf

2.2.2 Informational Self-Determination as a Foundation of Network Self-Determination

In 1983, the German Supreme Court recognised explicitly the individual right to "informational self-determination" as an expression of the fundamental right to have and develop a personality, enshrined in Article 2.1 of the German Federal Constitution. It is important to stress that this right is not a German peculiarity and is formally recognised under international law. Indeed, article 22 of the Universal Declaration of Human Rights affirms that "everyone is entitled to the realisation of the rights needed for one's dignity and the free development of their personality," while the International Covenant on Economic, Social and Cultural Rights consecrates this fundamental principle with regard to the human right to education and to participate in public life. Particularly, the Covenant's signatories have agreed that the right to education "shall be directed to the full development of the human personality and the sense of its dignity [...] and enable all persons to participate effectively in society" (Article 13.1). Moreover, the free development of personality is explicitly considered as instrumental to exercise the fundamental right to "to take part in cultural life [and] to enjoy the benefits of scientific progress and its applications" (Article 15).

Importantly, since the eighties, the right to informational self-determination has become a cornerstone of personal-data protection. Indeed, the reasoning of the German Court stressed that the right to informational self-determination underpins "the capacity of the individual to determine the disclosure and use of his/her personal data,"[16] thus ascribing to individuals the right to choose what personal data about themselves can be disclosed, to whom, and for what purposes such data can be used. In this context, it must be noted that, over the past twenty years, the exercise of informational self-determination has been increasingly challenged by the transformation of the collection and processing of personal data into the main source of income of the majority of Internet services. Although Internet

16 See "Census" decision, BVerfGE, para. 65.1.

access and data collection have been traditionally treated as separated issues, it is increasingly evident that this is not the case anymore. To understand why these issues are increasingly intertwined and why informational self-determination is also a conceptual basis of network self-determination, it is important to clarify three major points.

First, the business models of most online services and mobile applications rely on the collection and monetisation of users' data, rather than being based on the payment of a fee, which, on the contrary, is the core source of revenue in the subscription model, traditionally utilised by Internet access providers. Although the "zero price" business models of online services presents such services as "free," it is widely recognised that users *de facto* pay the price with their personal data, which are collected and monetised for various purposes, such as user profiling for targeted advertising.[17] This model is highly lucrative and, for this reason, over the past decade, authors and institutions have incessantly stressed that "data is the new oil"[18] and that personal data are "the new currency of the digital world,"[19] a "new asset class"[20] and "the world's most valuable resource."[21]

Second, it must be noted that many users do not realise the value of their personal data nor the fact that that these data represent the price of the online services they access "freely". Furthermore, the strong majority of users are not aware of the implications of the collection and processing of their personal data, being submerged by unread[22] contractual terms and complex privacy notices to which they carelessly consent, in

17 For an extensive analysis of how Internet companies collect, combine, analyse and trade individuals' personal data, see Christl (2017).

18 The phrase was coined by the British mathematician Clive Humby, in 2006, and was subsequently made popular by the World Economic Forum 2011 report on personal data. See WEF (2011).

19 See Kuneva (2009).

20 See WEF (2011).

21 See The Economist (2017).

22 As noted by a study conducted by MacDonald and Cranor (2008) "individuals should spend 8 h a day for 76 days every year to read the privacy policies of the websites they visited on average." It is worth noting that, since the popularisation of smartphones, the number of terms of services agreed upon by users has possibly doubled, considering that to the websites regularly accessed one has to add a conspicuous number of mobile applications.

order to enjoy the supposedly "free" services.[23] For instance, the majority of users ignore that their personal data are utilised to record and manage their behaviour in real-time and to take a wide spectrum of very sensitive decisions on themselves, such as assessing credit applications and determinations of creditworthiness based on their digital behavioural data.[24] In his context, it seems important to make a third consideration. Over the past years, the collection of personal data has become so relevant and strategic that several players have started applying the logic of the zero-price model to Internet access offerings, starting to sponsor limited access to specific applications, presented as "free" – because their data consumption is not counted against users' monthly data-allowance – but *de facto* paid by users via the collection of their personal data. Indeed, individuals' personal data have become such a valuable asset that business players are becoming ready to sponsor access to their applications to be able to collect and utilise the data produced by the (new) users of such applications.

The abovementioned offerings are generally categorised as "zero rating"[25] plans and are presented by some stakeholders as a potential solution to "connect the unconnected."[26] However, it should be noted that, despite rhetoric, the purpose of most of these offerings is not philanthropic but rather to orientate user experience into predefined applications,[27] the access to which will be paid by users with their "free labour"[28] as data producers, rather than with money. Indeed, in light of the value of (personal) data, it may be worth for a corporation to sponsor access to its applications in order to concentrate the production of users' data, which are the real price paid by users to access digital services.

23 For a critical perspective on the notice-and-consent model enabling the bulk collection of data online and a proposal of a user-centred data management model, see Belli, Schwartz and Louzada (2017).

24 These elements, amongst many others, are thoroughly analysed by Christl (2017).

25 For an analysis of zero rating models, see Belli (2016b).

26 This slogan is particularly utilised by the private sector (e.g. GSMA 2016) but has also been integrated by more institutional venues, such as the ITU. See, for instance, ITU (2017).

27 I define such phenomenon as "Minitelisation of the Internet." See Belli 2016b and 2017.

28 For an analysis of the value produced by application users' free labour, see Beverungen, Böhm and Land (2015).

Notably, users' personal data may be particularly valuable when users are previously unconnected individuals, about which no data has ever been collected. In this sense, one of the reasons why zero-rating plans have been criticised as "digital colonialism"[29] is the way they intervene in developing markets, encouraging the use of specific – and usually foreign – applications, rather than encouraging connectivity. Fostering the use of a limited set of applications may be seen as a strategic move to create new loyal data-producers rather than new Internet users that may develop potentially competing applications. In this respect policymakers in developing countries should carefully considered that sponsored applications *de facto* drain "the most valuable resource" out of a country in exchange of access to few applications. Such model takes considerable advantage of the fact that individuals in developing countries cannot afford an alternative and that both individuals and policymakers seem to be completely unaware of the tremendous value that personal data generate and will keep on generating in the future for those who exploit them.

On the contrary, CNs foster network self-determination, for they allow individuals to decide autonomously how to pursue their economic, social and cultural development, without having to trade personal data for services. The goal of CNs is indeed to empower community members that will become new active participants of Internet, thus enjoying the benefits of connectivity while contributing to the Internet's evolution in a bottom-up fashion. Numerous examples[30] of different CN formats demonstrate that CNs are not only feasible, but they can also be scalable and trigger a wide range of positive externalities for the local communities that build them. Importantly, such positive externalities include the creation of an ample range of new services. As I will stress in the next section, existing examples of CNs suggest that these initiatives are valuable for capacity-building purposes, improving digital literacy and access to knowledge, as well as for the production and circulation of local

29 See Chakravorti (2016); Shearlaw (2016).

30 For an overview of CN governance, regulation and technical architectures, see Belli (2016a).

content and applications, thus reviving local economies or even generating entirely new economies.

Therefore, CNs play a significant role in promoting individual rights, in general, and the right to self-determination of peoples and informational self-determination, in particular. First, CNs foster freedom of expression and of association. Second, they strengthen informational self-determination, since CN members are not obliged to trade personal data for access. Third, the establishment of CNs regularly entails the inclusion of local community members into ICT education experiences, which allow them to learn how to develop new services, tailored on the community necessities, thus maximising Internet generativity.[31] This latter point crucially explains the relevance of CNs, which can truly empower previously unconnected communities, triggering a virtuous circle of knowledge-and-innovation sharing, while furthering individuals' freedom of expression and freedom to conduct a business.

The following section will offer evidence that the development of CNs can prompt several positive externalities that may considerably enhance the standards of living of individuals, creating learning opportunities, establishing efficient social organisations and stimulating local entrepreneurship.

2.3 Positive Externalities of Community Networking

There is widespread recognition amongst CN developers and scholars that CNs are positive contributors to the local socio-economic environments.[32] Besides providing access to information and knowledge, CNs specifically focus on the needs of local communities, providing community-tailored services while allowing community members to advertise and sell their products and services both locally and globally. Participants of many CNs have developed a variety of tools aimed at organising the community life in a more efficient way, for instance providing maps or shared planning tools,

31 The concept of generativity can be defined as "a system's capacity to produce unanticipated change through unfiltered contributions from broad and varied audiences." See Zittrain (2008: 70).

32 See *e.g.* Belli (2016a).

but also providing services spanning from messaging applications and social-networking platforms to music or video broadcasting applications and local e-commerce platforms.

Hence, CN initiatives have the potential to both revive local economies and reinvigorate community engagement in local politics, while making local administrations more efficient. These latter points become particularly relevant when we consider that the areas affected by lack of connectivity are frequently also the most affected by recession.[33] In this perspective, it becomes even more interesting to assess the potential benefits that CNs may deploy regarding local economy and governance, with particular regard to promoting employment opportunities for the local populations.

Even in developed countries such as the US, hundreds of communities and millions of individuals are disconnected or can only choose amongst a limited range of offerings, which are frequently too expensive, unreliable or include prohibitive data caps. Approximately 19 million Americans are in these conditions and, in rural areas, "nearly 20 percent lack access even to service at 4 Mbps/1 Mbps [and] 31 percent lack access to 10 Mbps/1 Mbps."[34] In this context, CNs become a very viable option to avoid social and economic exclusion of those – especially rural – communities that would otherwise be condemned to lag far behind the rest of the connected country. This if one of the reasons why CNs are springing up in the US, driven by the belief that "if I can get people at home going to school online, I can raise up my education attainment level, which is only going to help me attracting employers in the long run [and] there are so many economic and social benefits of this."[35]

---

33 As highlighted in figure 1, the U.S. example shows that rural unemployment is not only higher than urban unemployment but it is also accompanied by a decrease of population, which may further exacerbate the negative effects of unemployment. See USDA (2016). Similar considerations have been put forward by reports released in other countries hit by recession, as stressed by the UK Local Government Association (LGA), according to which "jobseekers in the countryside have been hit harder by the recession than their counterparts in towns and cities." See LGA (2009).

34 See FCC (2016).

35 This perspective is shared by the vice-chair of the Letcher County Broadband Board. See Rogers (2017).

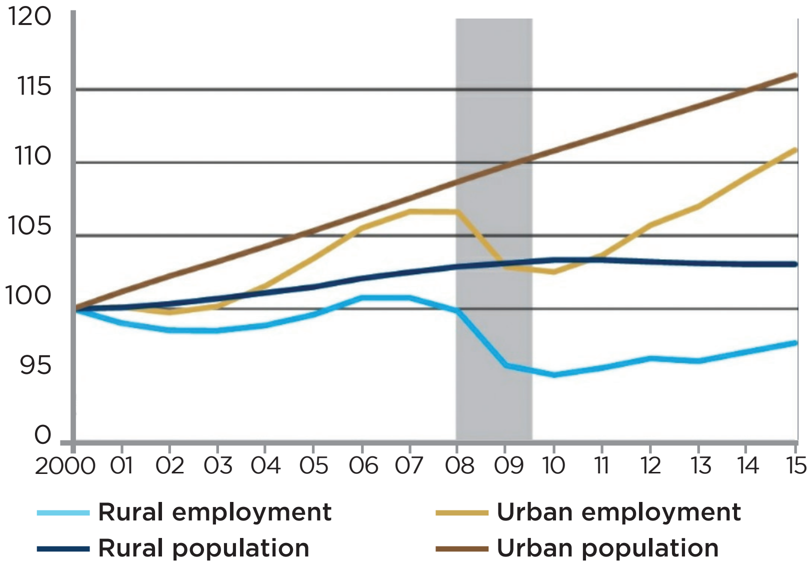


Figure 1: *Population and unemployment rate in rural and urban America.36*

CN debates and analyses frequently underappreciate the positive externalities generated by these networks, giving more prominence to the technology utilised to connect individuals or the governance model implemented to organise the CNs, rather than the concrete uses of connectivity and the benefits this may produce for the newly connected communities. The purpose of this section is to focus on the external effects of community networking and, to do so, I will scrutinise four examples of CN, established in four different countries presenting very diverse socio-economic environments. The examples have been chosen not only for their difference in size and technical features but also for the significant difference regarding industrialisation and average income amongst the countries where these CNs are established. Indeed, the CNs analysed in this section have been chosen to demonstrate that successful examples of community networking may be found and can be achievable in almost any kind of environment.

36 See USDA (2016).

2.3.1 Guifi.net

Guifi.net is the biggest CN in the world and probably the most renowned and most studied example of community networking.[37] Founded in 2004 as a telecommunications technology project in the Osona County, in Catalonia, Spain, the aim of Guifi.net has been, since the very beginning, to solve the broadband Internet access difficulties that rural areas frequently face, due to the reticence of traditional operators to deploy their networks in such regions.[38] It should be noted that Catalonia is one of the wealthiest areas of Spain, which is categorised as an advanced economy[39] and, in 2016, was ranked 26th amongst 174 ITU members, by the global ICT Development Index.[40] These elements are particularly important to understand the context in which Guifi.net was developed but also to emphasise that deployments of CNs are not limited to developing countries. On the contrary, low levels of connectivity may be common in developed and developing countries alike and, for this reason, the CN approach has very concrete applications in virtually every type of country.

As emphasised in figure 2, Guifi.net currently covers a broad area and has reached roughly 85,000 users that may be grouped in 34.000 active nodes, which have typically 2.5 users per node.[41] Indeed, as it happens in many CNs, every node corresponds to a household, which has usually 2.5 inhabitants in the areas spanned by Guifi.net. Besides being the biggest and the most populated CN in the world, Guifi.net is also particularly outstanding due to the great amount and variety of services[42] that its members have developed and use on a regular basis. Indeed, the Guifi.net original idea to deploy network infrastructure as common-pool resource,

---

37 For an in-depth analysis of Guifi.net, see Baig *et al*. (2015) and Baig *et al.* (2016).

38 See https://guifi.net/en/what_is_guifinet

39 See *e.g.* IMF (2017), according to which the Spanish GDP per capita in 2016 was $US 27,012.

40 See ITU (2016: 12).

41 In a communications network, a node is a connection point that can receive, create, store or send data along distributed network routes. Each network node – whether it is an endpoint for data transmissions or a redistribution point – has either a programmed or an engineered capability to recognise, process and forward transmissions to other network nodes. See http://searchnetworking.techtarget.com/definition/node

42 A complete list of services developed by the Guifi.net community can be found at https://guifi.net/node/3671/view/services

to be exploited in a fair and sustainable way, has favoured the establishment of "a disruptive economic model based on the commons model and the collaborative economy."[43] In this sense, it is interesting to note that the utilisation of a commons model to develop and manage network infrastructure has influenced other Internet layers, fostering collaborative application-and-content development. As Baig *et al*. (2015: 153) argue, the Guifi.net cooperative model is itself the reason why new, small, local entrants can easily develop new services, given the reduction of the entry costs and mutualisation of initial investments. Amongst the ample range of services developed by Guifi.net members, it is worth mentioning:

- 8 direct Internet gateways and 306 proxies;
- 48 Web servers;
- 31 File Transfer Protocol or shared disk servers;
- 13 Voice over IP servers;
- 13 broadcast radios;
- 6 instant messaging servers (jabbers) and 7 Internet Relay Chat servers;
- 5 videoconference servers;
- 4 mail servers.

In light of the above, an element that policymakers should consider carefully is the fact that, besides generating new content and services, CNs like Guifi.net can be net job creators. Indeed, Guifi.net demonstrates that, entrepreneurs and developers may be keen to develop and offer new services new services. Moreover, every CN needs to be maintained by a team of professionals, thus the mere establishment of a CN is likely to create jobs at least regarding the CN maintenance. In this perspective, Guifi.net has offered an employment to 37 certified professionals[44] and 13 non-professionally registered (*i.e.* non-full time) installers.

43 See https://guifi.net/en/what_is_guifinet

44 The certified professionals may be individuals or small and medium enterprises, thus elevating the number of persons employed by Guifi.net to several dozens, because every certified enterprise may employ up to 10 individuals.

Figure 2: Guifi.net nodes localisation as of July 2016.[45]

It is therefore important to note that CNs have the potential not only to provide affordable connectivity to previously-unconnected communities but also to resuscitate local economies, foster the creation of entirely new jobs, services and business opportunities. Furthermore, the development of CNs frequently entails the cooperation between CN members and local institutions such as local administrations, libraries, schools or universities. The case of Guifi.net is also emblematic in this regard, having established multistakeholder partnerships and cooperation with several hundred local institutions. Such high number of partnerships and widespread support from local stakeholders seems to be one of the key ingredients for the success of CNs.

2.3.2 Nepal Wireless Networking Project

The Nepal Wireless Networking Project (NWNP) was established in 2002 with the original aim of providing Internet access and telephony services to the Himanchal Higher Secondary School, an education institute in the Nepali district of Myagdi. (Pun *et al.*

45 See https://guifi.net/en/node/2413/view/map

2006) Differently from the Guifi.net example, NWNP is located in one of the poorest and least developed countries in the world. In fact, Nepal presents very high unemployment rate[46] and was ranked 142nd amongst 174 ITU members by the 2016 global ICT Development Index.[47] In this context, initiatives aimed at enhancing connectivity for the benefits of local populations are not only very welcome but they have the potential to enhance dramatically the life standards of the affected communities.

Shortly after NWNP was created, the CN founder, Mahabir Pun, decided to set more ambitious goals, aiming at bridging digital divides "from a grassroots perspective"[48] and, over the course of the years, NWNP turned into a social enterprise dedicated to bringing the benefits of wireless connectivity and ICTs to the populations living in several mountainous areas of Nepal. Importantly, the visionary strategy of Mahabir Pun considered connectivity as propellant for socio-economic development of the local communities and combined the construction of network infrastructure with the organisation of capacity-building programmes and with the development of services that could respond to the needs of the local populations.

Figure 3: *a NWNP tower is installed on a Nepali Himalayan peak.*[49]

46 See the World Bank overview of Nepal, available at http://data.worldbank.org/country/nepal#cp_wdi

47 See ITU (2016: 12).

48 See Pun *et al.* (2006:4).

49 See http://www.nepalwireless.net/index.php

Critically, the integrated approach consecrated by NWNP considered and stimulated the positive externalities of connectivity *ab initio*, thus establishing wireless infrastructure with the explicit purpose of going beyond selling Internet-access subscriptions. In this perspective, the aim of NWNP is the sustainable empowerment of the local community through the fulfilment of five different goals:[50]

- To allow **reliable communications** in the less accessible areas of Nepal through the provision of Voice over IP services, email applications and the organisation of a Nepali language bulletin boards, facilitating community discussions while simultaneously fostering e-governance;
- To increase **educational opportunities** for local community members through the establishment of e-learning programmes and trainings aimed at overcoming the shortage of qualified teachers in the rural areas, while creating local intranets allowing to access and share pedagogic material;
- To allow **access to quality healthcare** by providing telemedicine programmes and remote medical assistance. Importantly, this point was implemented in partnership with several hospitals;[51]
- To **foster e-commerce** allowing villagers to trade their locally produced goods by creating an online version of local market-places, supported by local intranets;
- To **generate jobs** with a particular focus on the younger generations, thanks to the provision of capacity building programmes made available in local tele-centres.

It seems needless to state that this integrated approach is precisely what makes CNs or any other connectivity effort successful. Policymakers willing to design a sustainable connectivity agenda should simply copy and paste the bullet-points mentioned above. Notably, NWNP has proved to be particularly successful because of the great number of very diverse start-up initiatives it has generated over its 15 years of life. Several social enterprises including e-agriculture, medical-content-provision applications and smart environment services have been developed thanks to

50 See Pun *et al.* (2006:5-7).

51 See http://www.nepalwireless.net/content.php?id=63

NWNP, improving the standard of life of thousands of individuals in numerous ways. As an instance, villagers regularly explore the e-agriculture application Haatbazar to organise local farming activities such as yak raising and cheese production, while local farmers have been using NWNP to trade livestock, to receive veterinary advice and access up-to-date veterinary information. Furthermore, to stimulate usage of ICTs by women, the NWNP team started developing pregnancy-related content that could be easily shared via feature phones. Such strategy proved so successful in fostering acceptance and use of technology by women that an Android-based application called Amakomaya was recently developed to deliver medical information to pregnant women via smart phones. Lastly, several weather stations have been connected to NWNP, to provide instant meteorological information to local communities while helping to enhance the local anti-poacher surveillance system, developed by NWNP members to monitor the Chitwan National Park, thus protecting several endangered species.

2.3.3 Telecomunicaciones Indígenas Comunitarias A.C.

Telecomunicaciones Indígenas Comunitarias Asociación Civil[52] (TIC-AC) is an initiative run by the NGO Rhizomatica.[53] The work of Rhizomatica consists in creating and promoting open-source technology that helps people and communities build their own networks. Simultaneously, Rhizomatica develops and supports governance strategies aimed at implementing the sustainable development of CNs and the local communities. TIC-AC was founded in 2013 and its successful example of CN deploying GSM infrastructure played a pivotal role in demonstrating the interest of and need for a policy framework facilitating CNs in Mexico. Decision 73/2016[54] of the Federal Telecommunications Institute of Mexico (FTI) institutionalised the possibility to establish CNs, creating the first telecommunication service license for “social indigenous use,”

52 See https://www.tic-ac.org/

53 Established in 2009, Rhizomatica aims at making alternative telecommunications infrastructure possible for people around the world dealing with oppressive regimes, the threat of natural disaster, or the reality of living in a place deemed too poor or isolated to cover. See https://www.rhizomatica.org

54 See Comunicado 73/2016 available at http://tinyurl.com/ycjx3awj

which allowed the installation of GSM-based CNs in the Mexican states of Oaxaca, Chiapas, Veracruz, Guerrero and Puebla. The FTI Decision has been hailed as an historic resolution, being the first formal act in the world to institutionalise a telecommunication license for social indigenous use.[55]

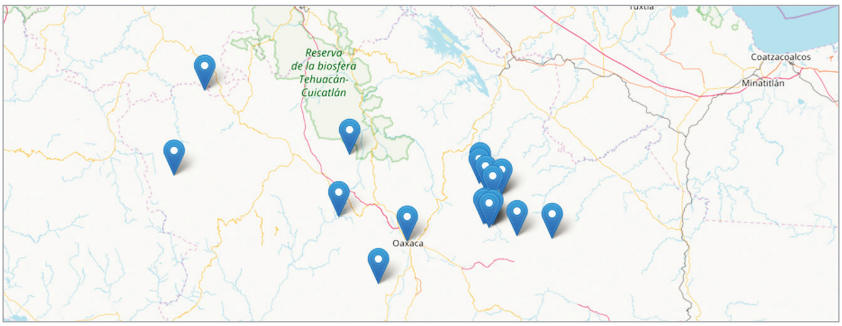


Figure 4: *localisation of the communities connected by TIC-AC*[56]

Although Mexico is considered an emerging market[57] and is currently ranked 92nd amongst 174 ITU members, by the global ICT Development Index,[58] it is important to note that the state of Oaxaca, where TIC-AC is established, is amongst the least developed in the Mexican federation.[59] The Oaxaca state is in the south of Mexico and is renowned for its most rugged terrains, with mountain ranges, narrow valleys and canyons. Such orographic configuration, together with a low population density, have traditionally been considered as an obstacle to the deployment of telecom infrastructure. On the other hand, the same factors have helped preserving indigenous culture, making the state population one of the most diverse in the country, accounting for 53% of Mexico's total indigenous language

55 Although Comunicado 73/2016 is the first regulatory act to officially adopt the term "social indigenous use" license, it must be noted that the development of CNs to connect indigenous communities has been pioneered by the Kuh-ke-nah Network (K-Net) that, since 2001, enables First Nations, peoples to communicate and build new skills in the Ontario province, Canada. See http://grandopening.knet.ca/

56 See https://wiki.rhizomatica.org/index.php/Main_Page/es

57 See, for instance, IMF (2017).

58 See ITU (2016: 12).

59 According to the Mexican Institute of Statistics and Geography, the GDP per capita of the Oaxaca state in 2015 was equal to $US 3,615. See INEGI (2015).

speaking population.[60] In this context, the double purpose of TIC-AC is to provide connectivity while letting the local populations self-determining how their network infrastructure should be organised and utilised to meet their needs, allowing a sustainable development and preserving their culture.

TIC-AC is a GSM-technology based CN that caters communication services to roughly 3000 users. Amongst the services developed by the TIC-AC community, Voice over IP applications are probably the ones having the greatest impact, allowing community members to communicate and organise themselves as well as to stay in contact with relatives migrated abroad for a small fraction of the price previously needed to afford domestic and international calls. The project is run by a team of nine and supported by 20 more individuals, which are employed as managers of the 20 networks composing TIC-AC. Hence, in addition to the provision of telecommunications services and Internet connectivity, TIC-AC has also created 29 direct jobs for the local community, while fostering the development of new services for the local communities. Importantly, the project has been so successful that other civil society actors have spontaneously replicated it, using the same strategy to empower communities in other areas.[61]

2.3.4 QuintanaLibre

QuintanaLibre is a CN developed by the NGO AlterMundi and situated in the area of José de la Quintana, in the Argentinian province of Córdoba. Argentina is categorised as a developing economy[62] and, in 2016, was ranked 55th amongst 174 ITU members, by the global ICT Development Index.[63] In this context, AlterMundi helps small communities building their own communications infrastructure, thus bridging the digital divides that are severely affecting rural areas. Particularly, the AlterMundi

60 For an overview of the indigenous languages spoken in Oaxaca and of the number of speakers, see http://cuentame.inegi.org.mx/monografias/informacion/oax/poblacion/diversidad.aspx?tema=me&e=20

61 See, for instance, the SayCel cellular network Project, available at http://tinyurl.com/ycn3oksh

62 See, for instance, IMF (2017).

63 See ITU (2016: 12).

model[64] aims at overcoming the challenges imposed by the rural environment in which CNs are frequently established. Since its inception AlterMundi has worked to design an effective, easy to implement and cost-efficient technology allowing to overcome the scarcity of networking experts, the reduced income[65] and the lack of infrastructure that generally characterise rural areas, while developing a replicable network architecture that may be easily transposed to any realities.

The QuintanaLibre network is structured in 70 nodes that provide Internet access to circa 280 connected devices. Although the CN is maintained through voluntary work, a number of grants have been obtained over time to develop the AlterMundi model and experiment it through the QuintanaLibre network. The AlterMundi association currently employs 15 people and several individuals have been hired to develop software, hardware and elaborate documentation, thus creating numerous jobs, since QunitanaLibre's creation, in 2012. Importantly, QuintanaLibre was established in the context of a collaboration between AlterMundi and the National University of Córdoba with the goal of sharing infrastructure and promoting research and development regarding CNs. The establishment of a 50-Km link allowing direct connection with the communications tower of the National University of Córdoba allows to freely exchange data, connecting the CN with the rest of the Internet. Particularly, this collaboration allows all AlterMundi-affiliated CNs to utilise the University's bandwidth when the University network is not utilised by students and academic personnel, during night and weekends, thus making an optimal use of a resource paid by public funds.

Importantly, QuintanaLibre members have developed several applications tailored on the needs of the local community, including a local information portal, a chat service, a VoIP server, community radio streaming, a file sharing system and several gaming applications. Moreover, the AlterMundi-affiliated networks

64 For an analysis of the AlterMundi network model, see Belli, Echánz & Iribarren (2016).

65 According to the World Bank, Argentina's GDP per capita was equal to $US 19,934, in 2016. However, data regarding rural Argentina may be significantly lower. See http://databank.worldbank.org/data/reports.aspx?source=2&series=NY.GDP.PCAP.PP.CD&country=

provide Internet access to three schools, which are connected through the regional network, as well as to public spaces such as squares, bus stops and local cultural centres.

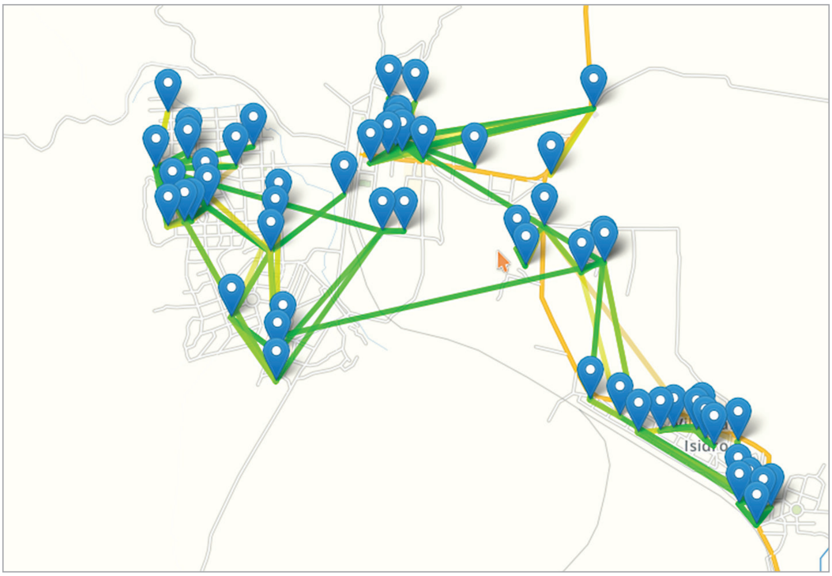


Figure 5: *the distribution of QuintanaLibre's nodes, as of July 2016.*[66]

AlterMundi's main server, housed within the datacentre of the University of Córdoba, is utilised to facilitate QuintanaLibre's services and to provide different services to other CNs, based both in Argentina and abroad. Such services have been developed in partnership with the Código Sur collective,[67] with the aim of providing infrastructure and development resources to local communities, prompting socialisation, organisation and knowledge-sharing amongst individuals. The partnership established in the context of Código Sur has been particularly fruitful, prompting the development of an ample range of free and open source applications, including hosting, streaming and mailing services as well as virtual private networking services.[68]

66 See http://bit.ly/2tmsutX

67 See https://www.codigosur.org/

68 See https://www.codigosur.org/servicios

2.4 Conclusions: Community Networks as Implementation of Network Self-Determination

The examples analysed in the previous section demonstrate that community networking initiatives can be successfully established in very diverse contexts. CNs may be considered as a prime example of how network self-determination can be implemented, empowering individuals with the possibility to reap the benefits of connectivity and deploying many positive external effects, able to enhance the quality of life of entire communities. Importantly, the fact that CNs are crowd-sourced initiatives does not only mean that individuals and organisations pool their resources and coordinate their efforts to build network infrastructures. It also means that the individuals involved in the design, implementation and maintenance of the CNs can learn and experience first-hand how Internet technology functions. As such, local populations previously excluded from the information society have the possibility to develop the capacities necessary to concretely benefit from connectivity, by communicating, acquiring knowledge and, most importantly, creating and sharing innovative applications and e-services that are tailored to meet the necessities of the local communities. Such initiatives have, therefore, the potential to give rise to entirely new socio-economic ecosystems, built by the local communities for the local communities and beyond, in a quintessentially bottom-up fashion.

However, it is also imperative to stress that the design, implementation and management of a CN should not be considered as trivial tasks and that the achievement of successful and sustainable CNs requires, first of all, vision and, secondly, the definition of a solid strategy and a reliable governance structure. These elements have allowed the analysed CNs to thrive in very dissimilar circumstances and should be considered as essential requisites for any community networking initiative. Furthermore, the analysed cases shown that the development of sustainable CNs frequently entails the cooperation with local institutions such as public administrations, hospitals, schools, universities or libraries. Multistakeholder partnerships with existing institutions can greatly reduce overhead while guaranteeing stability and, potentially, economic and organisational sustainability of the

CNs, mutualising costs and optimising resources. Moreover, this type of multistakeholder cooperation and engagement, involving public institutions, local civil society and local entrepreneurs, exemplifies meaningfully the positive externality that only CNs have been able to generate so far, reorganising local communities, creating business opportunities and strengthening social bounds amongst the locals.

It is worth highlighting that the latter elements are precisely what differentiates CNs from other "traditional" strategies, which have been proposed, to date, in order to "connect the unconnected." Indeed, differently from strategies typically promoted by expansionist business players to connect individuals, the goal of CNs is to let the local population self-determine how to interconnect, by building new infrastructure and new services in a democratic and bottom-up fashion, rather than "being connected" in accordance to strategies defined by external agents, whose principal interest is obviously not the one of the local community. In this perspective, the infrastructure built by the local populations should not be considered as the "last-mile" of the network but rather rather as the "first mile,"[69] which is autonomously developed and utilised by the empowered communities, where individuals enjoy the right to network self-determination.

As famously argued by Norberto Bobbio, human rights emerge gradually, for they reflect historical evolutions, being the results of "the battles human beings fight for their own emancipation and the transformation in living conditions which these struggles produce."[70] In such perspective, it is not absurd to argue that, just as individuals enjoy the fundamental rights to freedom of expression or to basic education, so they should also enjoy the right to network self-determination. There is indeed no reason why individuals should not be free to associate to define, in a democratic fashion, the design, development and management of network infrastructure as a common good, in order to freely seek, impart and receive information and innovation.

69 See Echániz (2015).

70 See Bobbio (1993:26).

Furthermore, as demonstrated by the examples analysed in this paper, the affirmation of a right to network self-determination is already happening *de facto* even before being consecrated *de jure*. Indeed, the proliferation of CNs offers a patent example of how individuals are willing and able to establish network infrastructure to improve their standards of life and to manage CN democratically, for the benefit of the community, when they are allowed to do so. Lastly, the analysed examples tellingly demonstrate that, when individuals with vision and a credible plan lead the efforts to expand connectivity, the result may be impressive. The magnitude of the positive externalities generated by CNs is particularly relevant when we consider connectivity as an essential means to empower people via education, communication, efficient organisation and new business opportunities. In this regard, the efforts of the UN IGF Dynamic Coalition on Community Connectivity[71] (DC3) are notable because they offer a shared understanding of what CNs are and how network self-determination can be enjoyed via the establishment of such networks.

More research and further cooperation are needed to unleash the potential of CNs but existing examples already demonstrate that CNs are a viable strategy to expand connectivity and empower people. Such examples also create a solid evidence-base on which the right to network self-determination can be constructed.

2.5 Acknowledgements

The author would like to express sincere gratitude to, in alphabetical order, Nicholas Echániz, Erick Huerta, Leandro Navarro and Mahabir Pun, for the precious information they were so kind to provide, regarding the CNs analysed in the second section of this paper. Sincere gratitude goes also to Carlos Rey-Moreno for the useful comments on the first draft of this paper as well as to Bruno Vianna and Ritu Srivastava for the complementary information they were so kind to provide.

71 See www.comconnectivity.org

2.6 References

Antunes Caminati, F., Diniz R., Orlova A., Vicentin D., Olivier P.J. and Lara M., Beyond the last mile: Fonias Juruá Project – an HF digital radio network experiment in Amazon (Acre/Brazil) in Belli, L. (Ed.) (2016a)

Baig, R. *et al.* (2015). Guifi.net, a Crowdsourced Network Infrastructure Held in Common. In Computer Networks. N° 90. http://dx.doi.org/10.1016/j.comnet.2015.07.009

Baig, R. *et al.* (2016). Making Community Networks economically sustainable, the guifi.net experience. GAIA '16 Proceedings of the 2016 workshop on Global Access to the Internet for All. http://dl.acm.org/citation.cfm?doid=2940157.2940163

Belli, L. (Ed.) (2016a) Community Connectivity: Building the Internet from Scratch Annual Report of the UN IGF Dynamic Coalition on Community Connectivity. http://tinyurl.com/comconnectivity

Belli, L. (Ed.) (2016b). Net Neutrality Reloaded: Zero Rating, Specialised Service, Ad Blocking and Traffic Management. Annual Report of the UN IGF Dynamic Coalition on Network Neutrality. Rio de Janeiro: FGV Direito Rio Edition. http://tinyurl.com/zerorating

Belli, L. (2017). "Net Neutrality, Zero rating and the Minitelisation of the Internet." Journal of Cyber Policy. Routledge. Vol. 2. N°1. http://dx.doi.org/10.1080/23738871.2016.1238954

Belli, L., Echánz N. and Iribarren G. (2016). Fostering Connectivity and Empowering People via Community Networks: the case of AlterMundi. In Belli L. (Ed.) 2016a

Belli, L. Schwartz M., Louzada L., (2017). Selling your Soul while Negotiating the Conditions: From Notice and Consent to Data Control by Design. In The Health and Technology Journal. Vol 5. N° 4. Springer-Nature. https://link.springer.com/article/10.1007/s12553-017-0185-3

Beverungen, A., Böhm S., Land C. (April 2015) Free Labour, Social Media, Management: Challenging Marxist Organisation Studies. Organisation Studies. Vol 36, Issue 4. https://doi.org/10.1177/0170840614561568

Bobbio, N. (1993). L'età dei diritti. Turin: Einaudi, 1993. Translated by Cameron A. (1996). The Age of Rights. Polity Press: Cambridge.

Chakravorti, B. (16 February 2016). Lessons from Facebook's Fumble in India. Harvard Business Review. https://hbr.org/2016/02/lessons-from-facebooks-fumble-in-india

Christl, W. (June 2017). Corporate Surveillance in Everyday Life: How Companies Collect, Combine, Analyse, Trade, and Use Personal Data on Billions. A Report by Cracked Labs, Vienna. http://crackedlabs.org/dl/CrackedLabs_Christl_CorporateSurveillance.pdf

Cristescu, A. (1981). *The right to self-determination*: *historical and current development on the basis of United Nations instruments.* Study prepared by Aureliu Cristescu, Special Rapporteur of the Sub-Commission on Prevention of Discrimination and Protection of Minorities. United Nations. New York. http://www.cetim.ch/legacy/en/documents/cristescu-rap-ang.pdf

Echániz, N. (2015). Community networks: Internet from the first mile. In FRIDA: 10 years contributing to development in Latin America and the Caribbean. http://lacnic.net/frida/FRIDA-book2015-en.pdf

FCC. (29 January 2016). 2016 Broadband Progress Report. https://www.fcc.gov/reports-research/reports/broadband-progress-reports/2016-broadband-progress-report

GSMA (9 February 2016). Connecting the Unconnected: Unlocking Human Potential through the Power of the Mobile Internet. https://www.gsma.com/newsroom/blog/connecting-the-unconnected-unlocking-human-potential-through-the-power-of-the-mobile-internet/

IMF (2017). World Economic Outlook Database. Washington, D.C.: January 16, 2017. https://www.imf.org/external/pubs/ft/weo/2016/01/weodata/index.aspx

INEGI. (2015). Producto Interno Bruto Per Cápita por Entidad Federativa. http://www.inegi.org.mx/est/contenidos/proyectos/cn/pibe/tabulados.aspx

ITU. (2016a). ICT Facts and Figures 2016. http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2016.pdf

ITU. (2016b). Measuring the Information Society Report 2016. http://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2016/MISR2016-w4.pdf

ITU. (2017). Working together to achieve Connect 2020 Agenda Targets. A background paper to the special session of the Broadband Commission and the World Economic Forum at Davos Annual Meeting 2017. http://broadbandcommission.org/Documents/ITU_discussion-paper_Davos2017.pdf

Kuneva, M. (31 March 2009). Keynote Speech. Rundtable on Online Data Collection, Targeting and Profiling. Brusseks, European Commission. http://europa.eu/rapid/press-release_SPEECH-09-156_en.htm

LGA (10 July 2009). Impact of recession on countryside must not be overlooked. http://tinyurl.com/y96bxmon

McDonald, A.M. and Cranor L.F. (2008). The Cost of Reading Privacy Policies. In I/S: A Journal of Law and Policy for the Information Society. 2008 Privacy Year in Review issue

Pun, M. *et al*. (September 2006). Nepal Wireless Networking Project. Case Study and Evaluation Report. http://lib.icimod.org/record/12552/files/4163.PDF

Rey-Moreno, C. (May 2017). "Supporting the Creation and Scalability of Affordable Access Solutions: Understanding Community Networks in Africa". Internet Society.

Rey-Moreno, C., Blignaut, R., May, J., & Tucker, W. D. (2016). An in-depth study of the ICT ecosystem in a South African rural community: unveiling expenditure and communication patterns. *Information Technology for Development*, *22* (sup 1), 101–120. http://doi.org/10.1080/02681102.2016.1155145

Rogers, K. (29 August 2017). Rural America Is Building Its Own Internet Because No One Else Will. Motherboard. https://motherboard.vice.com/en_us/article/paax9n/rural-america-is-building-its-own-internet-because-no-one-else-will

Saldana, J. *et al*. (Eds.) (August 2016). Alternative Network Deployments: Taxonomy, Characterisation, Technologies, and Architectures. Request for Comments: 7962. https://www.rfc-editor.org/rfc/rfc7962.txt

Shearlaw, M. (1 August 2016). Facebook lures Africa with free internet - but what is the hidden cost? The Guardian. https://www.theguardian.com/world/2016/aug/01/facebook-free-basics-internet-africa-mark-zuckerberg

The Economist. (6 May 2017). The world's most valuable resource is no longer oil, but data. https://www.economist.com/news/leaders/21721656-data-economy-demands-new-approach-antitrust-rules-worlds-most-valuable-resource

USDA. (November 2016). Rural America at a Glance. Economic Information Bulletin of the United States Department of Agriculture Economic Research Service. N° 162. https://www.ers.usda.gov/webdocs/publications/80894/eib-162.pdf?v=42684

World Bank. (2016). Digital Dividends. World Development Report 2016. http://documents.worldbank.org/curated/en/896971468194972881/pdf/102725-PUB-Replacement-PUBLIC.pdf

WEF. (January 2011). Personal Data: The Emergence of a New Asset Class. http://www3.weforum.org/docs/WEF_ITTC_PersonalDataNewAsset_Report_2011.pdf

Zittrain, J.L. (2008). *The Future of the Internet - And How to Stop It*. Yale University Press and Penguin UK. New Haven & London.

3 Barriers for Development and Scale of Community Networks in Africa

Carlos Rey-Moreno

This paper is based on content previously published in sections 1, 2 and 4 of Rey-Moreno C. (2017). Supporting the Creation and Scalability of Affordable Access Solutions: Understanding Community Networks in Africa. Internet Society.

Abstract

Community networks (CNs), communications infrastructure deployed and operated by citizens to meet their own communication needs, are being increasingly proposed as a solution to connect the unconnected. However, in Africa, where the proportion of unconnected is among the highest globally, the number of initiatives identified is relatively low considering the continent's size and population. This paper analyses the barriers that prevent more CNs from appearing or existing ones from becoming sustainable and scaling. The barriers identified range from the lack of awareness of both the potential benefits of accessing information, and the Internet more generally, and the possibility for communities to create their own network, to the lack of income of the people who would like to start one.

It is important to note, that most of the people within the next billion to be connected need to choose, daily, between Internet/communication networks and other vital necessities such a food and health. The unreliable (or the complete lack of) electricity in most of these areas, and the prohibitive cost of backhaul connectivity, also affects the capital required to start and operate one. The lack of local technical competencies, and a regulatory framework not conducive for the establishment of small, local communication providers, are also identified as the main barriers for growth of community networks in the region. Despite these breadth of barriers, African communities are proving that some, if not all, of these barriers have been addressed. This is motivating global organisations to contribute creating an enabling environment where these barriers are removed.

3.1 Introduction

There is widespread recognition of the opportunities and potential benefits of expanding access to the Internet, as included in the Sustainable Development Goal (SDG) targets[72]. Yet, around four billion people still lack access to it. Connecting the next billion users to the Internet is one of the central issues on the international Internet and Internet Governance agenda[73].

Despite the success of the mobile revolution in Africa, the market forces seem to be unable to provide affordable access to communications to the economically disadvantaged segments of the population, which ultimately hurts their access to information and further exacerbates existing digital divides. For instance, the GSMA has recently expressed that to justify the cost of deploying a base station, it requires more than 3,000 active users[74]. This, and other factors[75], have led governments, civil society, and the telecommunications industry to start looking for alternative solutions[76]. Community networks, which can be broadly defined as telecommunication infrastructure deployed and operated by citizens to meet their own communication needs[77], have been part of the foundations of the Internet infrastructure since the early days. In recent years, the community networks movement has grown consistently, leading more and more voices to point to them as a solution for connecting the next billion, due to increasing evidence of the role they do, and can, play[78].

The majority of the examples used to highlight the benefits of this model come either from Europe[79], or more recently, from Latin

72 Several SDGs address inequalities in access to the internet and ICTs, most significantly Target 5.b ("enhance the use of enabling technologies, in particular ICT, to promote women's empowerment") and Target 9.c ("significantly increase access to ICT and strive to provide universal and affordable access to internet in less developed countries [LDCs] by 2020"). See United Nations. Sustainable Development Goals. Available at: https://sustainabledevelopment.un.org/?menu=1300.

73 See Internet Governance Forum (2016).

74 See Internet Governance Forum (2016).

75 See Internet Society (2016).

76 See Saldana, J. et al. (2016)

77 See DC3. Working Definitions and principles. Available at https://www.comconnectivity.org/article/dc3-working-definitions-and-principles/

78 See Internet Governance Forum (2016).

79 See http://guifi.net/en/node/38392

America[80,81] and Asia[82,83]. On the African continent, where affordable access to communications is far from a reality, a recent survey that identified 37 community network initiatives in 12 African countries, only 25 of them being partially active[84].

This paper presents the barriers identified by experts and proponents of community networks that prevent more community networks from appearing on the continent.

3.2 Methodology

The results in this paper are mainly based on responses from the people who had been involved in community networks in Africa contacted to create the map available in Rey-Moreno and Graaf (2016). Those who were contacted were asked about the main barriers preventing them from happening. A total of 30 experts contributed, and their answers were thematically coded before being used. A list of participants is provided in Rey-Moreno (2017).

These results were complemented during a series of interactions with representatives of community networks in Africa in Nairobi, Kenya, from 22 to 24 November 2016:

- ISOC convened the first Summit on Community Networks in Africa on 22 November 2016[85], where representatives from ten of the 37 community networks identified were invited to present their initiatives. A list of participants is provided in Rey-Moreno (2017).
- One-on-one Interviews with the representatives conducted on 23 November.
- Panel session at the African Conference on Computer Human Interaction 2016 on 24 November[86].

80 See https://rhizomatica.org/

81 See https://www.altermundi.net/

82 See http://wforc.in/

83 See http://nepalwireless.net/

84 See Rey-Moreno; Graaf (2016).

85 See http://www.internetsociety.org/events/summit-community-networks-africa/2016

86 See Rey-Moreno et al. (2016).

3.3 Barriers to the Creation and Scale of Community Networks

The number of initiatives identified is relatively low considering the continent's size and population. Thus, it is important to understand the barriers that prevent more community networks from appearing or existing ones from becoming sustainable and scaling. The barriers identified by community network proponents and experts have been grouped into four umbrella categories: social, economic, technical, and legal.

3.3.1 Social

A lack of awareness of both the potential benefits of accessing information, and the Internet more generally, and the possibility for communities to create their own network, are the main barriers identified by the experts consulted that hinder the creation and scale of community networks. As Josephine from TunapandaNet emphasised:

> "We mostly look to the government to solve the issue of connectivity, but never have we seriously considered that the answer is in communities. I also think that a huge percentage of people living in rural areas still do not understand the power of connectivity and the impact it would have in their lives."

One of the main reasons cited for this gap is the lack of relevant local content on the Internet. As Fred Mweetwa, from Macha Works, summarised: "*Actually, what we see is that maybe 90% of the information you access on the Internet is foreign. But … what does Internet mean, to Africa; for Africans?*"

It is one thing to know about the Internet and the benefits of accessing the information available, but building infrastructure from the ground up to access it is another story. For the latter, it was argued that it takes considerable effort to change a mindset imposed after generations of colonial ruling. As a result, many are reluctant to engage in doing something different – not only in the communities, but in established businesses and other institutions, and other stakeholders relevant to community networks. For example, Zenzeleni Networks struggled for months to open a bank account because the bank managers in the closest town could not believe that people from rural areas were creating their own telecommunications cooperative. Similarly, the University of Johannesburg could not believe that people from Soweto were providing free access to the Internet by themselves. So, this lack of awareness is not only limited to rural areas and marginalised communities, but extends to those working or living in urban areas and more informed environments. They do not know that community networks are possible either. Many of those attending the first Summit or the follow-up panel did not know it is possible either, and this lack of awareness has been observed elsewhere by other experts after giving presentations about community networks.

Additionally, the advantages to set up community networks are not very clear to many. As Sebastian Büttrich, involved in the Sengerema Wireless Community Project in Tanzania, rhetorically asked: "*Why build networks if you already have mobile connectivity?*" His question points again to lack of awareness of the potential benefits for a community to engage in this process, and a lack of awareness regarding technical infrastructures and how they work.

In this scenario, excluding exceptional cases, many community networks in Africa were started thanks to the assistance of people external to the community, with academic and research institutions having special representation. These initiatives face additional barriers, as depending on the local partner, issues around gatekeeping and political use of the partnership can arise[87]. This may undermine the efforts from those in the community with the enthusiasm, time, and skills required to overcome the barriers mentioned in this section.

3.3.2 Economic

As Patrick Gichini from TunapandaNet said: "*Here in Africa, sometimes it goes down to the question of choosing between Internet/communication networks and other vital necessities such as food and health.*" Thus, if people need to make this type of decision with regard to personal expenditure on communications,

87 Local partners can use this initiative to further their position or political aspirations within a given community. This combined with the lack of knowledge about local politics by the external facilitators can effectively exclude other community members who are important for the sustainability of the community network.

it is difficult to imagine how they will be able to buy their own devices to create a community network, which is the case of most similar initiatives in high-income areas. Concerning the costs of telecommunications infrastructure, it is important to bear in mind the additional costs required, such as the power infrastructure needed due to the unreliability or nonexistence of the electricity grid in most of the places where these projects exist or could be deployed. The cost of this energy infrastructure, composed of solar modules and battery banks in most cases, accounts for more than 70% of the capital required (Wiens 2016). Additionally, telecommunications equipment is not even available domestically in many countries and needs to be imported. Most participants at the first Summit pointed to the high costs associated with import taxes and the customs bureaucracy as another barrier for them.

The amount of initial capital needed depends on the area that a community wants to cover, but in general terms – and due to the explosion of low-cost telecommunication devices – it is less than what people may think[88]. In addition to the cost of setting up and powering the local telecommunications infrastructure, if the community would like to connect the network to the Internet, it needs to face the high costs of backhaul connectivity, which in 2017 can still go as high as 1,000 USD per megabit per second (Mbps) for an Asymmetric Digital Subscriber Line (ADSL) type connection in some rural areas. Thus, even if the community manages to secure seed capital to cover the capital expenditure (CAPEX), creating sustainable business models by people without adequate training to cover the recurrent payments for the backhaul connectivity becomes challenging. To many of the people interviewed, this cost presents one of the biggest barriers for higher uptake of the community networks model, as it requires a considerable level of aggregated demand to make it cost effective. This, in turn, makes it more difficult for community networks to scale.

Meeting the cost of the backhaul makes it even more difficult to generate sufficient revenue to financially reward those involved in the management of the network. Those involved in the community

88 There are WiFi routers available in the market for less than 80 USD, with the high capacity LibreRouter, particularly designed for community networks having 100USD as its maximum costs. Depending on the electricity supply, and the terrain and the area that wants to be covered, total cost of ownership of a community network will vary.

networks in Africa analysed do it more as a community service; however, it is customary that when they spend a day working outside their home, they should receive some sort of stipend in return. Thus, voluntary work may work for a while, but people need to be remunerated to continue engaging in the long term.

The slow, if existent, adoption of Internet-abled user devices (mobile phones, tablets, computers, etc.) was also another barrier that was consistently mentioned, as they are very expensive for the low-income earners in most of these areas.

3.3.3 Technical

The lack of local technical competencies was often mentioned as the main barrier to the creation and scale of community networks in this dimension. Patrick Byamungu from Pamoja Net summarised this by stressing: "*In many of these communities in Africa where communication is a huge problem, the residents do not have the necessary knowledge [to] solve these problems and thus have to rely on outsiders for help in setting [up] their own networks.*"

Although there are notable exceptions, this is true for most of the community networks in Africa. In the best-case scenarios, those "*outsiders*" have trained locals on how to maintain, operate, and scale up the network. However, sometimes it is difficult to find people with the skills and the commitment to complete the training because "*[those] with knowledge leave to find better opportunities elsewhere, [and] those that have remained are too busy carving out a living for themselves,*" explained John Dada, from Fantsuam Foundation. "*[This creates] a perpetual cycle of training and retraining.*" Furthermore, the lack of electricity, as well as other physical infrastructure, poses an additional barrier to the execution of the technical trainings mentioned above.

Additionally, most of the participants attending the first Summit on Community Networks commented that electronic devices do not last long in their regions, which often means additional costs for maintaining or replacing equipment. Sometimes, this is due to heat affecting the routers used, as in the case of Namibia; to dust in the computers, as is common in the rural areas of Zambia or Zimbabwe; or the counterfeit and low-quality Ethernet cables detected in

Nigeria. The prohibitive cost and lack of local availability of rugged equipment prevents low-income communities from making use of them. Other materials required to set up a community network, such as electrical and solar equipment, poles, etc., are not available in a common hardware store in Africa, and expensive to import.

Another technical barrier listed is that existing technologies available to set up community networks are not well suited to the environments where some of the community networks are located. For instance, in Eenhana (Namibia), where the terrain is very flat and covered with tall trees, local communities could only use Wi-Fi[89], which requires line of sight (LoS) between the routers that create the network if they are at a certain distance. Similarly, in Kafanchan (Nigeria), where hills are common, Wi-Fi does not cater for those non-line of sight (N-LoS) scenarios.

3.3.4 Legal

The lack of policy and regulation facilitating the establishment of CNs was highlighted by most of the respondents as an important barrier. The reasons for this lack of support ranged from "total disinterest" or the lack of awareness that community networks are indeed possible, to having regulations in place that prevents or makes it difficult for community networks to exist. As Dada stressed:

> "An appropriate regulatory framework supported by informed national political will makes a lot of difference to the development and deployment of community networks in Africa. As one of the fastest-growing ICT markets globally, Africa can become a major hub for community networks if an enabling environment, comprising of adequate power and affordable Internet access, were made available."

However, and by looking at the series of Internet shutdowns in many African countries[90], it seems that governments are not interested in the growing evidence that the ICTs play in people's lives. That authoritarian view hinders discussions about community

89 In Namibia, as in many other countries in Africa, industrial, scientific, and medical (ISM) bands are the only ones that can be used on a license-exempt basis. See (Rey-Moreno *et al*. 2016).

90 See Rowlands (2016).

networks as the solution to provide affordable access, not only to the Internet *per se*, but to e-government services that the very same people that they are trying to target cannot access.

Global regulations can also have an impact in Africa. Type Approval of devices used in community networks in countries like South Africa requires compliance with United States Federal Communications Commission (FCC) and European Commission standards[91]. The last directives from the FCC[92] and the EC[93] that prevent changing the firmware of a given router, can have very negative consequences for the development of plug & play and low-cost devices to deploy these networks.

Another reason for this lack of support is the so-called regulatory capture mentioned by many of the respondents. This suggests that big telecommunications companies lobby to either create a regulatory framework that favours established operators and hinders the creation of CNs, or to prevent the application of the regulatory framework, thus in order to preserve the telecommunications companies' dominant and to perpetrate their anti-competitive practices. This effectively prevents new entrants, such as community network operators, to provide affordable access and compete on a level playing field.

Mamello Thindyane, formerly involved with the Siyakhula Living Labs in South Africa, and principal research fellow at the United Nations University Computing and Society, proposed another reason for legal and regulatory roadblocks:

> "Community networks are antithetical to the way big corporations and governments run – i.e., they are not about the concentration of power and control, but about distributing and decentralizing access to network resources. So, fundamentally and 'subconsciously,' they might not have much support from governments and private industry."

This was corroborated by Nicola Bidwell, from the University of Namibia, who locates community networks in a grey space that

91 See Ellipsis Regulatory Solutions (2017).

92 See Wiens (2016).

93 See Reda (2015).

is totally new for regulators, which in turn struggle to deal with them. This was further validated by the experience from Zenzeleni Networks, which faced a six-month delay in obtaining its license exemption, despite being assisted by one of the most experienced regulatory advisors in the country, simply because the regulator had not seen a case like that before.

According to the experts interviewed, the lack of more explicit support for the community network approach from regulators and policy-makers is combined with other regulatory barriers, namely:

- Small segments of the available spectrum are assigned for license-exempt use.
- Big segments of spectrum that are suited for N-LOS scenarios – i.e., the bands being freed up with the switch from analogue to digital TV and unused GSM spectrum – are allocated nationally but are effectively empty or unused in rural areas.
- Lack of, or limited, open-access national fibre backbones, which would facilitate the reduction of backhaul costs.
- High import duties and customs fees on telecommunications equipment and user devices.
- High regulatory fees on license-exempt wireless equipment purchase and use.
- Long waiting periods and costs[94] to obtain the permissions and licenses to deploy and operate such networks.
- Lack of clarity about whether part of the Universal Service and Access Funds could be used for these types of initiatives.

At the same time, community network representatives did not appear to be well versed in the local policy environment regulating their activities either. This lack of knowledge may become an additional barrier as their activities could be compromised by not complying with certain regulations or legislation, while at the same time failing to be considered as a serious alternative to receiving the aforementioned support from governments and regulators since they, as many representatives emphasised, “do not speak the same language”.

94 Free not-for-profit licenses are still exceptional.

3.4 Conclusion

The barriers presented in the previous section show the multiple challenges that community networks are facing in the continent. Still, as shown in Rey-Moreno (2017), there are many instances in different countries where some, if not all these barriers have been addressed and overcome. As such, communities in Africa are not simply deploying and operating telecommunications infrastructure to meet their own communication needs; but they are using them as a tool to improve what a community is already doing in terms of their growth and development, by contributing to a local ecosystem that improves the daily lives of the community members. Notably, some of these communities have gathered for two years in a row creating a movement to share their experiences and support each other to address these barriers more effectively.

These are not the only reasons to believe that this movement has the potential to expand rapidly. The ongoing technological advancements are simplifying deployments, operationalisation and scalability. Additionally, there is an increasing awareness of the value and impact of community networks, as well as the evidence that the work can be done locally by locals. This, in turn, is motivating many global organisations to consider community networks as reliable partners and to commit resources to actively work together with existing community networks to address some of the aforementioned barriers. Such tendency is proving to be particularly beneficial, inspiring Africans to make sure that their communities can benefit from the positive outcomes generated by community networks.

3.5 Acknowledgements

This paper, as the report it belongs to, is the result of a collective effort. It was only be possible thanks to the input from representatives of the community networks and other participants who attended the first Summit and the panel on community networks at the AfriCHI conference, and the experts and proponents who assisted identifying community networks and barriers (a list of them is provided in the full report). The report improved considerably thanks to the feedback from those who read its initial versions: Connie Kendig, Matthew Ford, Carl Gahnberg, Konstantinos

Komaitis, Dawit Bekele, Jane Coffin, Betel Hailu, Maarit Palovirta, Michael Oghia, Mike Jensen and Leandro Navarro. Special thanks to Michuki Mwangi for making the report itself possible.

3.6 References

DC3. (2017). Working Definitions and Principles. https://www.comconnectivity.org/article/dc3-working-definitions-and-principles/

Ellipsis Regulatory Solutions. (2017). Guide: Commonly-used Licence-exempt bands in South Africa which may be used for outdoor wireless access systems. May 2017. https://www.ellipsis.co.za/guide-to-commonly-used-licence-exempt-frequency-bands-in-south-africa/

Internet Governance Forum. (2016). Policy Options For Connecting & Enabling The Next Billion(s): Phase II (2016 edition). http://www.intgovforum.org/multilingual/index.php?q=filedepot_download/3416/412

Internet Governance Forum. (2016). Policy Options For Connecting & Enabling The Next Billion(s): Phase II (2016 edition).

Internet Society. (2016). Promoting Content in Africa. 2016. http://www.intgovforum.org/multilingual/index.php?q=filedepot_download/3416/57

Reda, J. (2015). Dear European governments: don't endanger free and open WiFi networks! Available at https://juliareda.eu/2015/10/dear-european-governments-dont-endanger-free-and-open-wifi-networks/

Republic of Namibia. (2011). Government Gazette No. 4839, No. 395 of 2011, dated 25 November 2011.

Rey-Moreno, C. (2017). Supporting the Creation and Scalability of Affordable Access Solutions: Understanding Community Networks in Africa, May 2017, Internet Society. ISBN 978-0-692-89777-5.

Rey-Moreno, C. *et al.* (2016). Community Networks in the African Context: Opportunities and barriers". AfriCHI, 21st-25th November 2016, Nairobi, Kenya. ACM, 2016.

Rey-Moreno, C., Graaf, M. (2016). Map of Community Networks in Africa. In Belli, L. (Ed.) "Community Connectivity: Building the Internet from Scratch". 1st Report of the Dynamic Coalition on Community Connectivity.FGV Rio Editions. December 2016.

Rowlands, L. (2016). Africa: More Than 50 Internet Shutdowns in 2016. http://allafrica.com/stories/201701050563.html

Saldana, J. *et al.* (2016). RFC 7962. Alternative Network Deployments. Taxonomy, characterisation, technologies and architectures, Working Group Document in the IRTF GAIA (Global Access to the Internet for All) group. Aug. 2016. https://www.rfc-editor.org/info/rfc7962

Surana, S. *et al.* (2008). Beyond Pilots: Keeping Rural Wireless Networks Alive. 5th USENIX Symposium on Networked Systems Design and Implementation, pages 119–132, 2008.

United Nations. (2015). Sustainable Development Goals. https://sustainabledevelopment.un.org/?menu=1300

Wiens, K. (2016). "Way to go FCC now manufacturers locking routers". http://www.wired.com/2016/03/way-go-fcc-now-manufacturers-locking-routers/

4 Community Networks as a Key Enabler of Sustainable Access

Michael J. Oghia

Abstract

This paper defines sustainable access to the Internet, as the ability for any user to connect to the Internet and then stay connected over time, thus contributing critically to sustainable development. The paper argues that Community networks are ideal to catalyse sustainable access, but the challenge of generating reliable energy to power infrastructure continues to pose a significant barrier to lowering costs and the ability to scale. This chapter aims to highlight the link between community networks and the broader agenda on sustainability, defines sustainable access, and explores the connection between infrastructure, energy, and Internet access, while concluding by outlining the role of community networks as a pillar of enabling sustainable access.

4.1 Introduction

Even before the launch of the 17 Sustainable Development Goals (SDGs)[95] in 2016, connecting the next billion individuals to the Internet – as well as the billions after that – had become a cornerstone of the Internet governance agenda (ISOC 2017; IGF 2016). Given that the United Nations declared that access to the Internet is a human right (UNHRC 2016),[96] a key pillar of the U.N.'s Sustainable Development Agenda[97] includes providing universal, inclusive, and meaningful access to the Internet, especially for those individuals who are unconnected (IFLA 2017; ISOC 2017).[98] As of late 2016, more than 3.5 billion people were connected to the Internet (Broadband Commission 2016), but this only represents around 49% of the total global population – approximately 4 billion people do not have access to the Internet. Moreover, many developed markets have reached saturation, while the clear majority of those individuals

95 Available at https://sustainabledevelopment.un.org/sdgs.

96 For more information, see Howell & West (2016).

97 See http://www.un.org/sustainabledevelopment/development-agenda/.

98 For more information, see Sustainable Development (2015).

who are unconnected reside in developing economies, largely in the Global South (Broadband Commission 2016).

Connecting the unconnected to the Internet presents substantial challenges, however. McKinsey & Company (2014) identified four major barriers to Internet adoption:

1. Incentives to go online;
2. Low incomes and affordability;
3. User capability; and
4. Infrastructure.

These barriers are especially problematic since "approximately 2 billion people, or nearly half the offline population, reside in 10 countries that face significant challenges across all four barrier categories – [Bangladesh, Egypt, Ethiopia, India, Indonesia, Nigeria, Pakistan, the Philippines, Tanzania, and Thailand]. An additional 1.1 billion people live in countries in which a single barrier category dominates [3.1 billion in total]" (McKinsey & Company 2014:6).[99]

This is compounded by the fact that the lack of Internet access is a key driver of inequality (ISOC 2017), as Franquesa & Navarro (2017:66) poignantly stressed:

> It is well established that there is an access gap between citizens who can afford a digital device and an Internet connection and those who cannot. Citizens unable to access digital tools are too often confined to the lower or peripheral edge of the society for economic or geographic reasons, such as living in underserved areas without access to digital interaction. As a result of this inaccessibility, such groups are denied full involvement in mainstream economic, political, cultural, and social activities.

99 Brazil provides a relevant case study explaining the phenomena described. Of the more than 211.3 million Brazilians, only around 139.1 million (66.4%) have regular access to the Internet. Although approximately 99.7% of all Brazilians have access to consistent and reliable electricity as of 2014, much of which is supplied by hydroelectric sources, the other three barriers unrelated to infrastructure pose significant challenges to connectivity in Brazil. According to an annual ICT survey that was conducted by the Brazil-based Regional Center for Studies on the Development of the Information Society (CETIC) in 2014, the unavailability or unaffordability of Internet services were not considered significant barriers to access. Instead, 70% of those involved in the study cited a lack of interest or need to go online, while 70% also cited the dearth of ICT, media, and digital literacy skills as significant reasons for being unconnected. For more information, see Jimenez (2015).

The large disparities in access to infrastructure, information and communications technologies (ICTs), and information that exist only serve to exacerbate poverty and inequality as well (Article 19 2017; ISOC 2017; McKinsey & Company 2014), including both Internet infrastructure as well as electric power – another critical element of infrastructure (The Economist Intelligence Unit 2017).[100] For instance, according to World Bank (2016b:2), even though "more households in developing countries own a mobile phone than have access to electricity or clean water, and nearly 70% of the bottom fifth of the population in developing countries own a mobile phone," more than 1.1 billion people around the world still have no access to electricity (UN 2016:22) – a veritable prerequisite for Internet access[101] – about half of whom live in Africa, according to the World Bank.[102] This infers that some people across the Global South own a mobile phone but do not necessarily have access to electricity in their homes to charge it.

Clearly, connecting another billion people to the Internet will require more than an Internet-connected device; such an endeavour requires significant long-term vision, investment in both technology and human capacity building, as well as communities committed to ensuring their access is useful, meaningful, and sustainable. For this to occur, however, such communities must be invested in the process of connectivity – from energy access, to network set up and maintenance – as well as leading this process based on their own needs, context, and developmental challenges.

This process would be significantly hindered if not for community networks (CNs). As one of the most significant vehicles for connectivity, community networks are at the forefront of connecting the next billion and a crucial component of sustainable development (e.g. Belli 2016). Designed to be community-driven, open, freely accessible, resilient, durable, neutral, and self-sustainable, community networks "have emerged as an increasingly popular means to providing public access, particularly for rural

100 For the full index, see https://theinclusiveinternet.eiu.com/explore/countries/performance.

101 For additional statistics on percent of country populations with access to electricity, see http://data.worldbank.org/indicator/EG.ELC.ACCS.ZS.

102 See Feinstein (2016).

communities, and are an important strategy for governments to consider as part of a policy framework to achieve universal access" (A4AI 2017:20).[103] Community networks, which are effectively crowdsourced computer networks, are particularly important to expanding access by addressing market failures or providing connectivity in unserved or underserved areas.[104] In fact, "The coverage of underserved areas and the fight against the digital divide are the most frequent driving factors for [the] deployment [of community networks]" (Navarro 2016:10).[105]

Community networks undoubtedly empower the unconnected – on their own terms, and based on their unique needs and local context – and are crucial to ensuring the next billion Internet users come online in a sustainable way. Given the infrastructural challenges faced, among others, how can the Internet Governance Forum (IGF) community in general and the Dynamic Coalition on Community Connectivity (DC3)[106] in particular assist community networks to become champions of sustainable models of Internet access? Moreover, what is needed to help build sustainability directly into community networking models, especially as it relates to energy generation?

4.2 From Sustainable Development to Sustainable Access

The sustainable development community's focus on technology tends to centre on how it is used to improve well-being, quality of life, information monitoring, and data management – referred to as information and communications technologies for development (ICT4D). Yet, for all the benefits ICT4D solutions promise, they also have the potential to harm communities and the environment by generating electronic waste (e-waste)[107] and greenhouse gas

103 For more information about community network working definitions and principles, see Community Connectivity (2017).

104 For an expanded list of active community networks, see https://goo.gl/oahE3H.

105 For a history of community networks and their development, see de Rosnay (2016).

106 See https://comconnectivity.org.

107 For more information, see: WHO (2017), Baldé, Wang, & Kuehr (2016), Baldé, Wang, Kuehr, & Huisman (2015), StEP Initiative (2014), and Greenpeace International (2009).

(GHG) emissions[108] even though it is meant to reduce such waste and pollution (Scharlemann *et al.* 2016; Tjoa & Tjoa 2016; ETSI 2015; GeSI 2015; ISOC 2015; European Commission 2014; APC & Hivos 2010). As ISOC (2015:7) highlighted:

> [The] environmental impacts of the Internet are crucial to sustainability. The Internet enables environmentally positive energy savings through improved efficiency, virtualisation of goods and services, and smart systems to manage productive processes. However, ICTs are also the fastest growing source of physical waste and greenhouse gas emissions. Their impact will increase as cloud computing[109] and the Internet of things (IoT)[110] become more widespread.[111]

Thus, we cannot legitimately discuss Internet access without addressing sustainability. In order to do so, however, a necessary step must be to shift the discourse from ICT4D to ICT for sustainability (ICT4S), which integrates sustainability more prominently to better reflect sustainable development[112] – especially as it relates to how ICT4D will evolve in terms of priorities and practice in the post-World Summit on the Information Society (WSIS) 10-year review period (Heeks 2014).[113]

4.2.1 Defining Sustainable Access

Sustainable access refers to **the ability for any user to connect to the Internet and then stay connected over time**.[114] This term was formulated during a roundtable workshop that was held during

108 To better understand the existing landscape of methodologies and initiatives used to measure and report about GHG emissions, the carbon footprint, and energy footprint for the ICT sector, see: European Commission (2013b). Additional information, specifically for the private sector, is available at https://www.ictfootprint.eu/.

109 For more information, see Greenpeace International (2012).

110 Current estimates place the growth of the IoT at a staggering 20.4 billion devices by 2020, which is the conservative figure – some estimates place it much higher. For more information, see Gartner (2017).

111 For more information, see GeSI (2015).

112 Buckridge (2017) specifically referenced this as it pertains to Internet governance as a whole as well.

113 For more information, specifically how it relates to relationship between development and Internet governance, see Oghia (2016b).

114 First referenced in Oghia (2017b).

the 2017 European Dialogue on Internet Governance (EuroDIG),[115] and is meant to transcend the important yet relatively narrow environmental or energy components and how they connect to global challenges such as climate change.[116] Instead, sustainable access encompasses various aspects of the relationship between technology, society, and the environment, including:

- The need for robust, durable, and reliable infrastructure, such as fibre optics, Internet exchange points (IXPs), high-speed connectivity, Domain Name System (DNS) root server mirrors,[117] and dependable electrical power sources;
- The kind of energy supplying critical Internet infrastructure, cooling servers, and powering ICTs;
- How much power ICTs are consuming, how such power is being generated, and the energy costs of data generation, storage, and transit;[118]
- The sourcing, manufacturing, and recyclability of Internet-connected devices/ICTs, as well as industry-related practices such as planned obsolesce;[119]
- Human-centric needs and skills, such as media & digital literacy and ICT skills, internationalised domain names (IDNs), easy-to-use and affordable services, local, relevant, and multilingual content, and community-led networking (community networks);[120]
- Digital pollution, the availability of resources such as radio spectrum, Internet Protocol (IP) addresses, and Autonomous System (AS) numbers, the implementation of IP version 6 (IPv6);

115 See https://eurodigwiki.org/wiki/WS_11_2017.

116 The definition also reflects the metrics reported in The Economist Intelligence Unit (2017) index, namely: availability, affordability, relevance, and readiness. For more information, including the full index, see https://theinclusiveinternet.eiu.com/.

117 See http://www.root-servers.org/. To learn how to host a root server mirror, see https://www.dns.icann.org/lroot/host/.

118 For more information, see Oghia (2017c).

119 Planned obsolesce is a purposely implemented policy of producing consumer goods with an artificially limited lifetime that rapidly become obsolete and so require replacing, achieved by frequent changes in design, termination of the supply of spare parts, and the use of nondurable materials. For more information, see: Remy & Huang (2014) and Forge (2007). Additionally, ETSI (2015) provided a meticulous and extensive set of requirements to reflect quality and standards that designers, engineers, manufacturers, and other related practitioners/stakeholders should strive for.

120 For more information, see Oghia (2016b).

- And lastly, the ecological impact the digital world is having, such as the impact of e-waste on both the environment and communities, the proliferation of "space junk," such as defunct satellites or other objects in low-Earth orbit that pose a significant hazard to satellite infrastructure and telecommunications,[121] and the relationship between climate change and the Internet/ICTs.[122]

Each of these components of sustainable access is meant to address a larger gap in current practices vis-à-vis development and ICTs – i.e., that facilitating access to the Internet and expanding connectivity in general must be a seen as a holistic, interconnected process involving multiple stakeholders. This it is vital this process catalyses a paradigm shift that integrates sustainability into its core, from the manufacturing process of an Internet-connected device and building a network, to the skills needed to successfully participate in the information society and how to effectively maintain, repair, and recycle ICTs. The logic behind sustainable access also considers the regulatory, legal, and policy landscape needed to enable real-world action on the ground in local communities as well as regionally and globally (e.g. IFLA 2017; ISOC 2017; Rey-Moreno 2017; Thomas, Remy, Hazas & Bates 2017).[123]

4.3 Power as a Prerequisite: Sustainable Energy for Internet Infrastructure

What is concerning is that since constant, reliable electricity is needed to power telecommunications infrastructure, Internet access itself will not be sustainable without a sustainable energy source (Armey & Hosman 2016).[124] This poses a significant challenge for community networks in particular since they often operate in rural, remote, underserved, and/or impoverished areas, often with little access to grid power.[125] Writing on behalf of the Digital

121 See Hall (2014).

122 For example, see Oghia (2016a).

123 Regulations and policies have a significant impact fostering enabling environments for development. Cox, Royston, & Selby (2016) posited that energy systems, for example, are not only affected by energy policies, but by a wide range of other policies as well.

124 For an overview of projected renewable energy generation growth as well as electrification trends around the world, see U.S. Energy Information Administration (2016).

125 Another notable exception is GSMA (2014).

Empower Foundation's (DEF)[126] experience in India, for instance, Srivastava (2016:144) stressed: "With many villages lacking stable power supply, finding a power source at the required location remains a challenge – in several cases solar power [is] the only solution."[127]

Although rather axiomatic, universal access to affordable, reliable, and modern energy sources is critical to sustainable development (Verolme 2017; Scharlemann *et al.* 2016; UN 2016; Armey & Hosman 2016; Magalini *et al.* 2016; Kuhnke 2015). In fact, as Kuhnke (2015:208) underscored: "Two of the main problems in the realisation of sustainable development are a comprehensive energy supply and the consequences related to energy use." This is not surprising since, according to the World Bank, energy – electricity in particular – is crucial to improving the standard of living for people in low- and middle-income countries, and modern energy services are central to the economic development of a country and to the welfare of its citizens … without such services, communities stagnate, and the potential for individuals to live healthy, productive lives is diminished (World Bank 2016:14).[128]

In a World Resources Institute (WRI) report featuring strategies for expanding universal access to electricity services for development, Odarno, Agarwal, Devi, & Takahashi (2017) offered solutions that many community networks may stand to benefit from – including an approach to closing the electricity access gap driven by the belief that electrification must respond to user demand and help improve lives. Moreover, the proposed solutions resemble the key tenant behind community networks: that they be community-led and community-driven. As a result, the authors suggested to:

1. Understand electricity demand from the bottom up;
2. Link electricity access with development priorities; and
3. Ensure electricity services are reliable, affordable, and of good quality.

126 https://defindia.org/.

127 For more information, see DEF's Wireless for Communities (W4C) program: http://wforc.in/wireless-for-communities/.

128 For an overview of energy generation per country, see World Bank (2017).

Thus, expanding access to both the Internet and energy can – and perhaps should – be done concurrently (Rubin 2017). Yet, it is important to bear in mind two challenges that exist as it relates to energy and sustainable Internet access: one that is short-term and one that is long-term. The short-term challenge regards the more straightforward need for expanded energy infrastructure and efficiency, especially in underserved and rural communities, while the long-term challenge regards the impact expanding Internet connectivity will have on the environment as a whole.

4.3.1 Short-term Challenge: Energy Infrastructure

Reliable electricity provision is anything but guaranteed in many developing countries (The Economist Intelligence Unit 2017). Given the largely interdependent relationship between energy and ICTs, unreliable electricity provision is a particular hindrance to Internet use in less developed African, Asian, and Caribbean countries – particularly those in Sub-Saharan Africa and parts of Asia[129] – and electric power often fails to be considered in national broadband development plans, for instance. Moreover, least developed countries (LDCs) and small island developing states (SIDS) often suffer the most due to large gaps in investment, specifically for sustainable energy and ICTs (UN-OHRLLS 2017), with only 15% of all households in LDCs with access to the Internet (ITU 2017b). Expanding on these realities, the Global Information Society (GIS) Watch 2016 report (APC & IDRC 2016) captured various energy-related problems for underserved communities, including how infrastructural and social determinants of Internet access, such as electricity, income, and illiteracy, create barriers to access (such as in Argentina and Benin), whereas other problems include the failure of the state to invest in energy infrastructure (such as in South Africa), barriers to e-health services due to lack of electricity (such as in Chile and the Republic of Congo (Brazzaville)), the need for a policy or policies to be developed that address upgrading the electricity grid (such as in Senegal), and focusing on rural energy infrastructure development (such as in Uganda, where access to electricity in the rural areas is only around 7%).

129 For more information, see Armey & Hosman (2016).

Yet, the report also highlighted positive developments, specifically regarding the interdependent relationship between electricity and the Internet as well as the power of collaboration with energy providers to ensure local connectivity. Such is the case in Costa Rica, where a local cooperative, whose original purpose was to provide electricity to a rural area in northern part of the country, now focuses on telecommunications and rural connectivity – further reinforcing the natural synergy that exists between energy infrastructure and ICT infrastructure. As a result, the cooperative has had a major role in reducing the digital divide in the area, and also created a popular local television channel to boost relevant content for the community in partnership with the local digital technology chamber (APC & IDRC 2016).

Elsewhere, The Economist Intelligence Unit (2017) underscored how some African governments are now paying attention to electricity supply in the context of inclusion. The Kenyan government, for example, is connecting most of the country's schools to the national grid as part of its digital literacy program. In another instance, ITU (2017a) emphasised that, when considering bridging the digital innovation divide in low income,[130] factor driven economies,[131] challenges abound with respect to enabling conditions for innovation.

Fortunately, solutions to such challenges already exist. They often involve green, renewable energy sources, such as solar and wind power. Solar power is particularly effective since it provides sustainable, affordable, efficient, emission-free energy (Harrison, Scott & Hogarth 2016; Evans, Strezov & Evans 2009),[132] but is also relatively low-maintenance, easy to set up and use, and generate "negligible" amounts of e-waste "in proportion to the quantity and environmental impact of the total e-waste stream" (Magalini *et al*. 2016). Many programs and initiatives also exist that leverage renewable energy or innovative technologies, such as DEF's

130 Classified as such by the World Bank.

131 Classified as such by the World Economic Forum (WEF).

132 For more information, see Scott, A. *et al.* (2016).

Barefoot College;[133] the Kenya-based BRCK initiative;[134] Mesh Power,[135] which operates in Rwanda, and provides power as well as data over power lines;[136] expanding smart grids, mini-grids, and low-cost, technical options to connect rural and remote residents to grid electricity;[137] the World Bank Group's pan-Africa-focused Lighting Africa project;[138] the rural Africa-focused, pay-as-you-go solar[139] providers Angaza,[140] Mobiisol,[141] and Fenix International;[142] the European Federation of Renewable Energy Cooperatives (REScoop),[143] Off Grid Electric, which provides clean energy in rural Tanzania and Rwanda;[144] and Solar Sister,[145] which operates in East Africa.[146]

Other solutions involve increasing innovation and energy efficiency, as exemplified by the European Union, which sets a high standard for policies related to energy efficiency.[147] Aside from policy and legislation, advances in analytics, automation, artificial intelligence (AI), machine learning, and the IoT are already exhibiting great promise in increasing efficiency and reducing data and energy consumption for many Internet technology-related areas. Conversely, however, many new Internet technologies – such as blockchain – do not necessarily address energy sustainability or take into account how these technologies will contribute to energy consumption over time as they scale.[148]

133 https://www.barefootcollege.org/solution/solar/.

134 https://www.brck.com/.

135 https://www.meshpower.co.uk/about.html.

136 This specific topic was discussed on the DC3 list as well, see this thread ("Collaborating with local power companies"): http://listas.altermundi.net/pipermail/dc3/2017-March/000774.html.

137 See Feinstein (2015) and Feinstein (2016).

138 https://www.lightingafrica.org/.

139 See Sanyal (2017).

140 See https://www.angaza.com/.

141 See http://www.plugintheworld.com/mobisol/.

142 See http://www.fenixintl.com/

143 See https://rescoop.eu/.

144 See http://offgrid-electric.com/.

145 See https://www.solarsister.org/.

146 For other examples of solutions, see: The Economist Intelligence Unit (2017).

147 See https://www.ictfootprint.eu/.

148 For more information, see http://digiconomist.net/bitcoin-energy-consumption, Malmo (2017), and Gubik (2017).

Essentially, different communities from around the world must adopt technology and/or other solutions – such as policy or regulatory ones (e.g., Thomas, Remy, Hazas & Bates 2017) – that fit their individual context and needs while being based on the resources they have available. For instance, ARMIX, an IXP based in Yerevan, Armenia, reached out to ISOC seeking ways to help them integrate renewable energy into their operations – since Armenia has ample sunlight throughout the year – and also to promote green energy solutions and reduce their electricity costs and consumption. ISOC eventually donated 18 solar panels that produce more than 4 kilowatts of power to help them with one of their points of presence (PoPs). As a result, ARMIX's electricity costs have dropped by more than 30%, and they are now much less reliant on non-renewable energy sources. In fact, the panels have been so helpful that ARMIX is now looking for ways to expand the use of solar to their other two PoPs. Their success not only highlights how sustainability is good for business, but is also an example of the achievements that can be realised through the combination of enabling government policy-making, effective public-private partnerships, and sustainable planning since the government began incentivizing solar energy adoption and a local solar panel company assisted ARMIX in installing them (Oghia 2017a).

Ultimately, many of the challenges addressed by the SDGs reflect global issues relevant to everyone, regardless of a country or community's state of development. Therefore, it is important to recognise that while each community has its own needs, there is value in connecting communities with those facing similar issues, especially if there are relevant solutions that have already been developed and implemented.[149]

4.3.2 Long-term Challenge: Energy Sustainability amid Data Growth

What is notably absent from the current discussions surrounding energy and the Internet is how the growth and proliferation

149 For an expanded take on how communities can collaborate more effectively to achieve sustainable development outcomes, see Oghia (2016c).

of ICTs will affect the amount of energy needed to power them (Oghia 2017c; World Bank 2016b; Hurst 2014; European Commission 2014, 2013a). It is estimated that ICTs account for around 10% of global electricity use (Oghia 2017c; Andrae & Edler 2015; Van Heddeghem *et al.* 2014), and are responsible for approximately 2-3% of all annual GHG emissions (Oghia 2017c; GeSI 2015; Hurst 2014; Malmodin *et al.* 2010). It is clear, however, that data use and generation is rising exponentially, which has a direct impact on energy (ITU 2017b; Widdicks *et al*. 2017; Hazas, Morley, Bates & Friday 2016). In fact, researchers from Lancaster University in the U.K. warned that the rapid growth of remote digital sensors and devices connected to the Internet and the IoT has the potential to bring unprecedented and, in principle, almost unlimited rises in energy consumed by smart technologies (Hazas, Morley, Bates & Friday 2016). Moreover, according to Lancaster University (2016):

> The increase in data use has brought with it an associated rise in energy use, despite improvements in energy efficiencies. Current estimates suggest the Internet accounts for 5% of global electricity use but is growing faster, at 7% a year, than total global energy consumption at 3%. Some predictions claim information technologies could account for as much as 20% of total energy use by 2030.[150]

Additionally, when considering connecting the next billion Internet users, it is equality important to consider the devices they will connect with. How are these devices going to be manufactured and eventually recycled (or will they simply be discarded)? Given that the Internet and ICTs are using more and more energy, what kind of energy is going to power the data centres and other critical Internet infrastructure feeding our increasingly data-hungry habits?[151] How do we satisfy growing energy demand in general,[152] and mitigate machine-to-machine (M2M), ICT, and data transit energy consumption,

150 For a detailed overview, see Oghia (2017c).

151 See Widdicks et al. (2017), Whitehead et al. (2014), and Greenpeace International (2012).

152 See http://www.demand.ac.uk/understanding-demand/.

which is rising as well, in particular?[153] And what about other related aspects of technology, such as the growing amount of natural resources like purified water needed to manufacture semiconductors,[154] or whether or not the minerals in Internet-connected devices are mined from conflict zones[155] – only to be shipped back one day to be dumped in a slum?[156] These are but a few of the myriad questions that are going unanswered, but ultimately, with more data comes more energy consumption and a greater impact on the environment.[157] Simply put, we are reaching a point in our civilizational arc where we can no longer ignore that digital technology has a significant ecological footprint, which is why sustainability must be integrated into the core of our infrastructure and ICT development strategies. We must also take steps to implement a circular economy focusing on common-pool resources, recyclability, and reducing waste (Franquesa, Navarro, & Bustamante, 2016), especially when deploying Internet infrastructure in remote locations within or surrounded by pristine natural conditions.

4.4 The Role of Community Networks

Community networks are paramount to developing and extending the concept of sustainable access for three primary reasons:

1 **Expanding access & building robust infrastructure:** The effort to connect the next billion would be significantly hampered without community networks, especially within developing economies in the Global South, impoverished and/or underserved areas (both rural and urban), and remote regions, specifically because they build infrastructure and provide the technical means to access the Internet;[158]

---

153 See Strengers, Morley, Nicholls, & Hazas (2016).

154 See http://engineeredenvironment.tumblr.com/post/30464844411/water-use-in-the-semiconductor-manufacturing.

155 Many are precious or rare earth minerals as well, including gold, tin, cobalt, tantalum, silver, and tungsten. For more information, see ITU News (2012), World (2012), and Fair Phone ([s.d.]).

156 See WHO (2017) and Baldé, Wang, Kuehr, & Huisman (2015).

157 See Andrae & Edler (2015).

158 Other technical factors include decreasing latency, providing access to backhaul (the fixed and wireless infrastructure that moves traffic between mobile sites within a region, and connects it to a backbone network), the availability of peering and local hosting/caching, access to spectrum, last-mile connectivity, etc. For more information, see Belli (2016).

2 **Providing reliable energy:** CNs generally operate in rural, remote, and/or other areas without access to grid power, often relying on alternatives like solar power instead to power infrastructure and devices; and

3 **Media & digital literacy, ICT skills, and technical capacity building:** CNs create spaces that encourage community building, such as through community centres, schools, libraries, or other public spaces,[159] as well as skill building, particularly for media & digital literacy and ICT skills that are vital to prolonged online participation[160] and civic engagement,[161] as well as technical skills needed to maintain the community network's infrastructure.

Although points one and three are equally as important for long-term sustainability, the second reason is the aspect that is the least discussed, in particular within the Internet governance ecosystem. In fact, although the need for a reliable and consistent energy supply to power a community network's infrastructure is relatively self-evident, it is seemingly often underemphasised within the CN community. While compiling this paper, for instance, I found few resources that could assist a community network in solving one of the most pressing yet relatively elementary and straightforward problems with building infrastructure: how to power it and keep it operational. Solar power was often stressed as the solution (e.g. Rey-Moreno 2017; Belli 2016; Srivastava 2016), and Butler et al. (2013) not only acknowledges this, but provided a detailed overview of how to integrate solar as well as various other types of off-grid power into a community network model.[162] Altermundi, a pioneering Argentina-based community network, offers another solution to address electrification that they use within their network: power over Ethernet (PoE) (Belli, Echániz & Iribarren 2016).

159 Such spaces are critical for capacity building. For more information, see IFLA (2017).

160 See UNESCO (2013).

161 See Martens & Hobbs (2013) and Mihailidis & Thevenin (2013).

162 A community network advocate from Mexico shared one example. A rural Mexican community wanting Internet access first had to solve its electrification problem since it was not connected to the grid and thus could not power the Internet infrastructure it needed. As a result, the community built a small and simple hydroelectric power generator from the village's water source with the help of external expertise that now provides power to both the village as well as its network infrastructure.

Undoubtedly, though, energy, the subsequent costs of infrastructure (both initial investments and upgrades), and the inability to recycle equipment or use it over the long-term can significantly hinder the sustainability and growth of a community network – as well as its ability to scale – while also adding unnecessary e-waste. Taking community network development in Africa into account, for instance, Rey-Moreno (2017:21) found:

> Concerning the costs of telecommunications infrastructure, it is important to bear in mind the additional costs required, such as the power infrastructure needed due to the unreliability or nonexistence of the grid in most of the places where these projects exist or could be deployed. The cost of this power infrastructure accounts for more than 70% of the capital required. Additionally, most [interviewees] … commented that electronic devices do not last long in their regions, which often means additional costs for maintaining or replacing equipment. Sometimes it is due to heat affecting the routers used in the case of Namibia, the dust in the computers, as is common in the rural areas of Zambia or Zimbabwe, or the fake Ethernet cables detected in Nigeria. The high cost and lack of local availability of rugged equipment prevents low-income communities from making use of them. Other materials required to set up a community network, such as electrical and solar equipment, poles, etc., are not available in a common hardware store in Africa and [are] expensive to import.

Regardless of the kind of energy solution and device infrastructure used, however, it is likely cost prohibitive. Such is the case throughout Africa where "additional funds are needed by community networks … to cover the lack of electricity in the locations where they are deployed, a lack that is usually covered by solar power systems" (Rey-Moreno 2017:30).[163]

Community networks also have a prominent role to play in promoting

163 This is a problem that the team behind BRCK in particular is working to address.

sustainability in general, from helping to implement effective ICT4D projects, such as weather monitoring, access to information about agriculture and the environment, or disaster preparation, to simply empowering communities with the ability to participate in the global information society and create their own local, environmentally responsible, do-it-yourself (DIY) circular economy. In fact, community networks represent a solution to two problems: the first being energy inefficiencies associated with powering global network infrastructure and delivering content/services over great distances, and the second being a driver of participation, inclusion, civic engagement, and environmental responsibility. Speaking to the former problem, Antoniadis (2016:9) emphasised:

> Seen from a long-term perspective, there are additional reasons why using a local network is a better solution when communication is meant to be local: resilience and sustainability. Second, when a local service is available through a central server (managing multiple such services) various energy inefficiencies are introduced. Many people might prefer to use their 3G/4G/5G connections, which are much more energy consuming than local Wi-Fi, data needs to be transferred over longer distances, stored, processed, analysed, and so on. It would not be surprising to realize that more energy is actually needed by a global platform to perform the tasks related to its commercial activities than the actual service. A small local network built only to serve a small group of people could be made to run only on locally generated renewable energy.

Franquesa & Navarro (2017:69) addressed the latter problem, arguing:

> The future of societies around the world depends on accessibility and participation – that citizens must be able to fully engage in the governance of the digital, not only as mere users or consumers. The current model of unequal access to digital devices and connectivity is clearly unfair and unsustainable. Too few participate

in the design and governance of the digital world, creating an elite of private interests. A minority of the world's population can enjoy the benefits of sleek devices and fast connectivity. Everyone is or will be influenced by the growing environmental impact of the digital world. If digitally excluded communities become peer-production actors, they will be able to build their own circular devices and sustainable network infrastructures, they will benefit from local reinvestment of surpluses, and they will have the opportunity to become active participants in the interactions of the design and governance of the common digital space.

4.5 Conclusion

If we truly want digital technology and the myriad emerging technological innovations that are beginning to scale to become ubiquitous, sustainability must be addressed more prominently as a core component. We cannot disregard or downplay sustainability with the hope that the inherent problems with our digitized world disappear – whether such problems are related to energy use, e-waste, device mineral sourcing, or low-earth orbit pollution (space junk). It is clear, however, that there are unexplored and underemphasised synergies and areas of collaboration between the energy and ICT sectors, which undoubtedly includes the Internet governance community, which could better address sustainability as a whole. As sustainability and access are intrinsically connected, the role of community networks in ushering in the next phase of the Internet's development should not be underestimated.

Moreover, and specifically regarding sustainable energy and reliable electrification, emphasizing the need for sustainable energy could provide a significant boost for both new and existing community networks as well as enrich both the community networking as well as wider development communities. More importantly, sharing experiences and best practices as to how this challenge was overcome and where, for instance, funding was sourced to cover it could be a substantial resource and way to assist as well. Ultimately, technological interventions are not a panacea in and of themselves (Gigler & Bailur 2014); they need to be backed by complementary investments in physical infrastructure, including electricity and literacy (World Bank 2016b:92). Community networks present an ideal solution to address this fact. With more financial, technical, policy, legal, and regulatory support, CNs are well positioned to continue to connect the unconnected while doing so in a sustainable manner, and advocating for sustainable access through on-the-ground practice to address real challenges facing communities around the world.

4.6 References

Alliance for Affordable Internet (A4AI). (2017). *A4AI affordability report 2017*. http://a4ai.org/affordability-report/report/2017/.

Andrae, A. S. G., & Edler, T. (2015). "On global electricity usage of communication technology: Trends to 2030." *Challenges*, *6*(1), 117-157. http://www.mdpi.com/2078-1547/6/1/117.

Antoniadis, P. (2016). Local networks for local interactions: Four reasons why and a wayforward. *First Monday*, *21*(12). http://firstmonday.org/ojs/index.php/fm/article/view/7123/5661.

Armey, L. E., & Hosman, L. (2016). "The centrality of electricity to ICT use in low-income countries." *Telecommunications Policy*, *40*, 617-627. https://www.researchgate.net/publication/273085058_The_centrality_of_electricity_to_ICT_use_in_low_income_countries.

ARTICLE 19. (2017). *Open development: Access to information and the Sustainable Development Goals*. https://www.article19.org/data/files/medialibrary/38832/Open-Development--Access-to-Information-and-the-SDGs-2017.pdf.

Association for Progressive Communications (APC) & International Development Research Centre (IDRC). (2016). *Global information society watch 2016: Economic, social, and cultural rights and the Internet*. https://www.giswatch.org/sites/default/files/Giswatch2016_web.pdf.

Association for Progressive Communications & Humanist Institute for Cooperation withDeveloping Countries (Hivos). (2010). Global Information Society Watch 2010: Focus on ICTs and environmental sustainability.: http://www.giswatch.org/sites/default/files/gisw2010_en.pdf.

Baldé, C.P., Wang, F., & Kuehr, R. (2016). *Transboundary movements of used and waste electronic and electrical equipment: Estimates from the European Union using trade statistics*. United Nations University, Rectorate in Europe – Sustainable Cycles Programme (SCYCLE): Bonn, Germany. http://www.step-initiative.org/files/step-2014/Publications/Green%20and%20White%20Papers/UNU-Transboundary-Movement-of-Used-EEE.pdf.

Baldé, C. P., Wang, F., Kuehr, R., & Huisman, J. (2015). *The global e-waste monitor 2014: Quantities, flows, and resources*. United Nations University, Institute for the Advanced Study of Sustainability: Bonn, Germany. https://i.unu.edu/media/unu.edu/news/52624/UNU-1stGlobal-E-Waste-Monitor-2014-small.pdf.

Belli, L. (Ed.). (2016). *Community connectivity – building the Internet from scratch: Annual Report of the UN IGF Dynamic Coalition on Community Connectivit*y. FGV Direito Rio: Rio de Janeiro, Brazil https://www.slideshare.net/FGV-Brazil/community-connectivity-building-the-internet-from-scratch.

Belli, L., Echániz, N., & Iribarren, G. (2016). "Fostering connectivity and empowering people via community networks: The case of Altermundi." In L. Belli (Ed.), (2016) pp. 31-53).

Broadband Commission. (2016). *The State of Broadband: Broadband catalyzing sustainable development*. International Telecommunications Union. http://www.broadbandcommission.org/Documents/reports/bb-annualreport2016.pdf.

Buckridge, C. (2017). "Internet governance for sustainability." *CircleID*. http://www.circleid.com/posts/20170619_internet_governance_for_sustainability/.

Butler, J. et al. (Eds.). (2013). *Wireless networking in the developing world* (3rd ed.). http://wndw.net/download/WNDW_Standard.pdf.

Cox, E., Royston, S., & Selby, J. (2015). *The impacts of non-energy policies on the energy system: A scoping paper*. UK Energy Research Centre. http://www.demand.ac.uk/wp-content/uploads/2016/07/The-impacts-of-non-energy-policies-on-the-energy-system-scoping-paper.pdf.

DC3 - working definitions and principles", *Community Connectivity*, Jul. 2017. Available at https://comconnectivity.org/article/dc3-working-definitions-and-principles/de Rosnay, M. D. (Ed.). (2016). *Network infrastructure as commons: Alternative communications networks throughout history*. Net Commons. http://netcommons.eu/sites/default/files/d5.1_history_v1.1.pdf.

European Telecommunications Standards Institute (ETSI). (2015). *Environmental Engineering (EE): Methodology for environmental Life Cycle Assessment (LCA) of information and communication technology (ICT) goods, networks, and services*. http://www.etsi.org/deliver/etsi_es/203100_203199/203199/01.03.01_60/es_203199v010301p.pdf.

European Commission. (2014). *Study on the practical application of the new framework methodology for measuring the environmental impact of ICT – cost/benefit analysis*. https://ec.europa.eu/digital-single-market/en/news/study-practical-application-new-framework-methodology-measuring-environmental-impact-ict.

European Commission. (2013a). *ICT footprint: Pilot testing on methodologies for energy consumption and carbon footprint of the ICT sector*. https://ec.europa.eu/digital-single-market/en/news/report-pilot-testing-methodologies-energy-consumption-and-carbon-footprint-ict-sector.

European Commission. (2013b). *Towards an overall measurement methodology of the carbon and energy footprints of the ICT sector*. https://publications.europa.eu/en/publication-detail/-/publication/9a79fd07-27af-4ad5-b39f-0fe11a49b9e5.

Evans, A., Strezov, V., & Evans, T. J. (2009). "Assessment of sustainability indicators for renewable energy technologies." *Renewable and Sustainable Energy Reviews*, *13*, 1082-1088. http://fossilhub.org/wp-content/uploads/2014/03/Evans_etal2009_sustainability_renewable_energy.pdf.

Fair Phone ([s.d.]), "Understanding the materials in mobile phones", *Fair Phone*, [s.d.]. Available at https://www.fairphone.com/en/project/understanding-materials-mobile-phones/.

Feinstein, C. (2015). "Three breakthroughs that can help bring power to over a billion people", *The world bank*, Mar. 2015. Available at http://blogs.worldbank.org/voices/three-breakthroughs-can-help-bring-power-over-billion-people

Feinstein, C. (2016). "Getting current: New tech giving more Africans access to electricity", *The World Bank*, May. 2016. worldbank.org/energy/getting-current-new-tech-giving-more-africans-access-electricity.

Forge, S. (2007). "Powering down: Remedies for unsustainable ICT. *Foresight*, *9*(4), 3-21. http://www.emeraldinsight.com/doi/pdfplus/10.1108/14636680710773795.

Franquesa, D. & Navarro, L. (2017). "Sustainability and participation in the digital commons." *Interactions*, *24*(3), 66-69. http://interactions.acm.org/archive/view/may-june-2017/sustainability-and-participation-in-the-digital-commons.

Franquesa, D., Navarro, L., & Bustamante, X. (2016). "A circular commons for digital devices: Tools and services in eReuse.org." In Proceedings of the Second Workshop on Computing within Limits (LIMITS '16), ACM: New York, NY. Article 3, 1-9. http://acmlimits.org/2016/papers/a3-franquesa.pdf.

Gartner (2017). "Gartner Says 8.4 Billion Connected "Things" Will Be in Use in 2017, Up 31 Percent From 2016", *Gartner*. https://www.gartner.com/newsroom/id/3598917.

Gigler, B.-S., & Bailur, S. (Eds.). (2014). *Closing the feedback loop: Can technology bridge the accountability gap?* World Bank. http://documents.worldbank.org/curated/en/100021468147838655/pdf/882680PUB0978100Box385205B00PUBLIC0.pdf.

Global e-Sustainability Initiative (GeSI). (2015). *#SMARTer2030: ICT solutions for 21st century challenges*. : http://smarter2030.gesi.org/downloads.php.

Greenpeace International. (2012). *How clean is your cloud?* http://www.greenpeace.org/international/en/publications/Campaign-reports/Climate-Reports/How-Clean-is-Your-Cloud/.

Greenpeace International. (2009). "Where does e-waste end up?" http://www.greenpeace.org/international/en/campaigns/detox/electronics/the-e-waste-problem/where-does-e-waste-end-up/.

Groupe Speciale Mobile Association (GSMA). (2014a). Green power for mobile bi-annual report 2014. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2014/08/GPM_August2014_FINAL.pdf.

Gubik, M. (2017). “Proof of Stake FAQ”, *Github*, Aug. 2017. https://github.com/ethereum/wiki/wiki/Proof-of-Stake-FAQ.

Hall, L. (2014). “The history of space debris.” *Space Traffic Management Conference*, Paper 19. http://commons.erau.edu/cgi/viewcontent.cgi?article=1000&context=stm.

Harrison, K., Scott, A., & Hogarth, R. (2016). *Accelerating access to electricity in Africa with off-grid solar: The impact of solar household solutions*. Oversees Development Institute: London, UK. https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/10229.pdf.

Hazas, M., Morley, J., Bates, O., & Friday, A. (2016). “Are there limits to growth in data traffic? On time use, data generation, and speed.” In Proceedings of the Second Workshop on Computing within Limits (LIMITS ‘16), ACM: New York, NY. Article 14, 1-5. http://limits2016.org/papers/a14-hazas.pdf.

Heeks, R. (2014). “ICT4D 2016: New priorities for ICT4D policy, practice, and WSIS in a post-2015 world.” Centre for Development Informatics, Institute for Development Policy and Management, University of Manchester. https://web.archive.org/web/20140702152748/http://www.seed.manchester.ac.uk/medialibrary/IDPM/working_papers/di/di_wp59.pdf.

Howell, C.; West, D. M. (2016). “The internet as a human right”. *TECHTANK*, Nov. 2016. https://www.brookings.edu/blog/techtank/2016/11/07/the-internet-as-a-human-right/.

Hurst, M. (2014). “How polluting is the Internet?” CCCB Lab. : http://lab.cccb.org/en/how-polluting-is-the-internet/.

International Federation of Library Associations and Institutions (IFLA). (2017). *Development and access to information 2017*. : https://da2i.ifla.org/sites/da2i.ifla.org/files/uploads/docs/da2i-2017-full-report.pdf.

Internet Governance Forum (IGF). (2016). *Policy options for connecting & enabling the next billion(s): Phase II*. https://intgovforum.org/multilingual/index.php?q=filedepot_download/3416/549.

Internet Society (ISOC). (2017). *A policy framework for enabling Internet access*. https://www.internetsociety.org/sites/default/files/bp-EnablingEnvironment-20170411-en.pdf.

Internet Society (ISOC). (2015). *The Internet and sustainable development*. https://www.internetsociety.org/doc/internet-and-sustainable-development.

International Telecommunication Union (ITU). (2017a). Bridging the digital innovation divide: A toolkit for strengthening ICT centric ecosystems. ITU Telecommunication Development Bureau (BDT) Innovation Service of the Innovation and Partnership Department. https://www.itu.int/en/ITU-D/Innovation/Documents/Publications/Policy_Toolkit-Innovation_D012A0000D13301PDFE.pdf.

International Telecommunication Union (ITU). (2017b). ICT facts and figures 2017. https://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2017.pdf.

ITU News (2012). "Conflitc minerals in the ICT supply chain", *ITU News*, 2012. https://itunews.itu.int/en/2854-Conflict-minerals-in-the-ICT-supply-chain.note.aspx.

Jimenez, M. (2015). "Explaining the digital divide in Brazil", *Internet Society*. https://www.internetsociety.org/blog/2015/09/explaining-the-digital-divide-in-brazil/.

Kuhnke, C. J. (2015). "Sustainable energy systems in developing countries: The implications of Sen's capability approach and Lund's choice awareness theory." In C. Ludwig, C. Matasci, & X. Edelmann (Eds.), *Natural resources: Sustainable targets, technologies, lifestyles, and governance* (pp. 208-213). World Resources Forum/Paul Scherrer Institute: Villigen PSI, Switzerland. https://www.wrforum.org/wp-content/uploads/2015/11/WRF-2013-2014-Natural-Resources.pdf.

Lancaster University. (2016). "World should consider limits to future Internet expansion to control energy consumption." *ScienceDaily*. www.sciencedaily.com/releases/2016/08/160811090046.htm.

Magalini, F. et al. (2016). *Electronic waste (e-waste) impacts and mitigation options in the off-grid renewable energy sector*. Evidence on Demand. : http://www.evidenceondemand.info/electronic-waste-impacts-and-mitigation-options-in-the-off-grid-renewable-energy-sector.

Malmo, C. (2017). "Ethereum Is Already Using a Small Country's Worth of Electricity", *Motherboard*, Jun. 2017. https://motherboard.vice.com/en_us/article/d3zn9a/ethereum-mining-transaction-electricity-consumption-bitcoin.

Malmodin, J., Moberg, Å., Lundén, D., & Lövehagen, N. (2010). "Greenhouse gas emissions and operational electricity use in the ICT and entertainment & media sectors." *Journal of Industrial Ecology*, *14*(5). https://www.researchgate.net/publication/227694154_Greenhouse_Gas_Emissions_and_Operational_Electricity_Use_in_the_ICT_and_Entertainment_Media_Sectors.

Martens, H., & Hobbs, R. (2013). "How media literacy supports civic engagement in a digital age." *Atlantic Journal of Communication*, *23*(2), 120-137. digitalcommons.uri.edu/cgi/viewcontent.cgi?article=1048&context=com_facpubs.

McKinsey & Company. (2014). *Offline and falling behind: Barriers to Internet adoption*. http://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/high%20tech/pdfs/offline_and_falling_behind_full_report.ashx.

Mihailidis, P., & Thevenin, B. (2013). "Media literacy as a core competency for engaged citizenship in participatory democracy." *American Behavioral Scientist*, *57*(11), 1,611 1,622. http://journals.sagepub.com/doi/pdf/10.1177/0002764213489015.

Navarro, L. (Ed.). (2016). *Network infrastructure as commons*: *Report on existing community networks and their organisation*. Net Commons. http://netcommons.eu/sites/default/files/attachment_0.pdf.

Odarno, L., Agarwal, A., Devi, A., & Takahashi, H. (2017). *Strategies for expanding universal access to electricity services for development*. World Resources Institute. http://www.wri.org/sites/default/files/Strategies_for_Expanding_Universal_Access_to_Electricity_Services_for_Development.pdf.

Oghia, M. J. (2017a). "Sustainability in Armenia: ARMIX adopts solar power." *Internet Society*. https://www.internetsociety.org/blog/development/2017/06/armix.

Oghia, M. J. (2017b). "Sustainability is good for the Internet (and business too)." *RIPE Labs*. https://labs.ripe.net/Members/michael_oghia/sustainability-is-good-for-the-internet-and-business-too.

Oghia, M. J. (2017c). "Shedding light on how much energy the Internet and ICTs consume." *CircleID*. www.circleid.com/posts/20170321_shedding_light_on_how_much_energy_internet_and_ict_consume/.

Oghia, M. J. (2016a). "The Internet's climate quandary and the inconvenience of practicing what we preach." *CircleID*. circleid.com/posts/20161006_the_internets_climate_quandary_inconvenience_of_practicing/

Oghia, M. J. (2016b). "WSIS, development, and Internet governance: A plea for 'Star Trek' over 'Mad Max.'" *CircleID*. circleid.com/posts/20160429_wsis_internet_governance_plea_for_star_trek_over_mad_max/.

Oghia, M. J. (2016c). "A 12-step guide to implementing the SDGs." *DiploFoundation*. https://www.diplomacy.edu/blog/12-step-guide-implementing-sdgs.

Remy, C., & Huang, E. M. (2014). Addressing the obsolescence of end-user devices: Approaches from the field of sustainable human computer interaction (HCI). In L. Hilty, & B. Aebischer (Eds.), *ICT innovations for sustainability: Advances in intelligent systems and computing, vol. 310* (pp. 257-267). https://link.springer.com/chapter/10.1007/978-3-319-09228-7_15.

Rey-Moreno, C. (2017). *Supporting the creation and scalability of affordable access solutions: Understanding community networks in Africa.* Internet Society. https://www.internetsociety.org/doc/cnafrica.

Rubin, N. (2017). "Without energy, the Internet is just a black hole: creating energy solutions for information and communications technology." Alliance for Affordable Internet. http://a4ai.org/without-energy-the-internet-is-just-a-black-hole-creating-energy-solutions-for-information-and-communications-technology/.

Sanyal, S. (2017). "'Pay-As-You-Go' Solar Could Electrify Rural Africa", *World Resources Institute*, Feb. 2017. Available at http://www.wri.org/blog/2017/02/pay-you-go-solar-could-electrify-rural-africa.

Scharlemann et al. (2016). *Global goals mapping: The environment-human landscape*. A contribution toward the United Kingdom Natural Environment Research Council (NERC), The Rockefeller Foundation, and ESRC initiative, *Towards a Sustainable Earth: Environment-human Systems and the UN Global Goals*. Sussex Sustainability Research Programme, University of Sussex, Brighton, UK, and UN Environment World Conservation Monitoring Centre, Cambridge, UK. http://www.nerc.ac.uk/research/partnerships/international/overseas/tase/mapping/.

Scott, A. *et al.* (2016). "Accelerating access to electricity in Africa with off-grid solar", *Odi*, Jan. 2016. Available at https://www.odi.org/publications/10200-accelerating-access-electricity-africa-off-grid-solar.

Srivastava, R. (2016). "A network by the community and for the community." In L. Belli (Ed.) (2016). pp. 125-146.

Solving the E-waste Problem (StEP) Initiative. (2014). *StEP white paper: Recommendations for standards development for collection, storage, transport, and treatment of E-waste*. United Nations University: Bonn, Germany. http://www.step-initiative.org/files/step/_documents/StEP_WP_Standard_20140602.pdf.

Strengers, Y., Morley, J., Nicholls, L., & Hazas, M. (2016). "The hidden energy cost of smart homes." *The Conversation*. https://theconversation.com/the-hidden-energy-cost-of-smart-homes-60306.

Sustainable Development (2015). "Transforming our world: the 2030 Agenda for Sustainable Development". *Sustainable Development Knowledge Platform*, 2015. https://sustainabledevelopment.un.org/post2015/transformingourworld.

The Economist Intelligence Unit. (2017). *The Inclusive Internet Index: Bridging digital divides*. https://theinclusiveinternet.eiu.com/assets/external/downloads/3i-bridging-digital-divides.pdf.

Thomas, V, Remy, C., Hazas, M., & Bates, O. (2017). "HCI and environmental public policy: Opportunities for engagement." In CHI '17 Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems. ACM, New York, NY, pp. 6,986-6,992. http://eprints.lancs.ac.uk/84117/.

Tjoa, A. M., & Tjoa, S. (2016). "The role of ICT to achieve the UN Sustainable Development Goals (SDG)." In Mata, F., & Pont, A. (Eds.), *ICT for promoting human development and protecting the environment* (pp. 3-13). WITFOR 2016. IFIP Advances in Information and Communication Technology, 481. https://link.springer.com/chapter/10.1007/978-3-319-44447-5_1.

United Nations (UN). (2016). *Global sustainable development report 2016*. UN Department of Economic and Social Affairs. https://sustainabledevelopment.un.org/globalsdreport/2016.

United Nations Educational, Scientific, and Cultural Organisation (UNESCO). (2013). *Global media and information literacy assessment framework: Country readiness and competencies*. http://unesdoc.unesco.org/images/0022/002246/224655e.pdf.

United Nations Human Rights Council (UNHCR). (2016). *Promotion and protection of all human rights, civil, political, economic, social, and cultural rights, including the right to development* (A/HRC/32/L.20). https://www.article19.org/data/files/Internet_Statement_Adopted.pdf.

United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries, and Small Island Developing States (UN-OHRLLS). (2017). *State of the least developed countries 2017: Follow-up of the implementation of the Istanbul Programme of Action for the Least Developed Countries*. http://unohrlls.org/custom-content/uploads/2017/07/State-of-the-LDCs_2017.pdf.

United States Energy Information Administration. (2016). *International Energy Outlook 2016*. Office of Energy Analysis, U.S. Department of Energy: Washington, D.C. http://www.eia.gov/forecasts/ieo.

Van Heddeghem, W. et al. (2014). "Trends in worldwide ICT electricity consumption from 2007 to 2012." *Computer Communications*, *50*, 64-76. http://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=F971419DBFBB26168150896821015DCC?doi=10.1.1.719.6370&rep=rep1&type=pdf.

Verolme, H. J. H. (2017). "SDG 7: Peoples' power or how to ensure access to affordable, reliable, sustainable, and modern energy for all." In Civil Society Reflection Group (Ed.), *Spotlight on sustainable development 2017: Reclaiming policies for the public* (pp. 78-83). https://www.2030spotlight.org/sites/default/files/download/spotlight_170626_final_web.pdf.

Whitehead, B., Andrews, D., Shah, A., & Maidment, G. (2014). "Assessing the environmental impact of data centres part 1: Background, energy use, and metrics." *Building and Environment*, *82*. https://www.researchgate.net/profile/Deborah_Andrews2/publication/269332368_Assessing_the_environmental_impact_of_data_centres_part_2_Building_environmental_assessment_methods_and_life_cycle_assessment/links/5775261808ae4645d60ba5bb.pdf.

Widdicks, K., Bates, O., Hazas, M., Friday, A., & Beresford, A. R. (2017). "Demand around the clock: Time use and data demand of mobile devices in everyday life." In CHI '17 Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems. ACM, New York, NY, pp. 5,361-5,372. http://eprints.lancs.ac.uk/84104/.

World (2017). "Conflict minerals: the bloody truth behind your smartphone". *News European Parliament*, Mar. 2017. http://www.europarl.europa.eu/news/en/headlines/world/20170314STO66681/conflict-minerals-the-bloody-truth-behind-your-smartphone.

World Bank. (2017). *World development indicators 2017*. https://openknowledge.worldbank.org/bitstream/handle/10986/26447/WDI-2017-web.pdf.

World Bank. (2016a). *World development indicators 2016*. http://databank.worldbank.org/data/download/site-content/wdi-2016-highlights-featuring-sdgs-booklet.pdf.

World Bank. (2016b). *World development report 2016: Digital dividends*. http://www.worldbank.org/en/publication/wdr2016.

World Health Organisation (WHO). (2017). *Inheriting a sustainable world? Atlas on children's health and the environment*. http://www.who.int/ceh/publications/inheriting-a-sustainable-world/en/

5 Can the Unconnected Connect Themselves? *Towards an Action Research Agenda for Local Access Networks*

Carlos Rey-Moreno, Anriette Esterhuysen, Mike Jensen, Peter Bloom, Erick Huerta* and *Steve Song

Abstract

Community based solutions to building local network infrastructure are increasingly being seen as viable alternatives to traditional large-scale national deployment models. Use of low cost networking equipment to provide communication infrastructure built in a bottom-up manner is growing, especially in rural areas where connectivity is poor. While there are instances of these solutions that stand as real-world examples of ways to improve access to ICTs and provide affordable and equitable access, these models of access provision are still not widely known or well accepted, usually being seen as "fringe" solutions to connectivity needs that lack widespread applicability or the potential to scale. This paper outlines a proposed action research agenda and methodology for providing an evidence-based understanding of the potential role of these types of local infrastructure solutions in meeting the needs of the unconnected, as well as those on costly-metered broadband services.

5.1 Introduction

According to the World Bank's "World Development Report 2016: Digital Dividends"[164], it is widely agreed that communications services based on mobile telephony and broadband are prerequisites for human development in the 21st century. Without connectivity, people face significant barriers for participating in the economic and social networks that comprise modern life. Universalising access has therefore become a policy priority in many countries, and is a core pillar of the UN Sustainable Development Agenda.[165] Several of the proposed Sustainable

164 World Bank Group (2016).

165 See http://www.undp.org/content/undp/en/home/sustainable-development-goals.html

Development Goals (SDGs) address inequalities in access to the internet and ICTs, most significantly Target 5.b ("enhance the use of enabling technologies, in particular ICT, to promote women's empowerment") and Target 9.c ("significantly increase access to ICT and strive to provide universal and affordable access to internet in less developed countries [LDCs] by 2020").

Nevertheless, despite the massive increase in the number of people connected through mobile telephony and data networks in the past decade, over four billion people remain unconnected to the internet, including around a billion who do not have access to basic telephony services.[166] And for the majority of those that are connected, affordability is still a major barrier to meaningful use. This digital gap is more acute for women, as it is estimated that 12% fewer women than men can benefit from internet access worldwide; rising to 15% in developing countries and almost 29% in least developed countries (ITU, 2016).[167] That figure jumps to 45% in sub-Saharan Africa, partly due to the costs of mobile broadband making up a higher percentage of women's income.

It has been widely assumed in the debate over how to achieve universal access to the internet that connecting the unconnected will largely take place through mobile broadband (3G and 4G/LTE). Most of the efforts to bring connectivity to the lowest income groups have presumed that by extending this business model, mobile broadband will eventually reach everyone, if necessary through government subsidies directed at supporting coverage in so-called 'unprofitable' areas.[168] But for many people in low-income groups and rural areas, this does not seem to be the case - the technical and business models of the national operators appear unable to reach universal coverage, despite over 20 years of operation, and services are still unaffordable for the lowest income groups. In Africa for example, the ITU

166 See http://www.itu.int/en/ITU-D/Statistics/Pages/facts/default.aspx

167 IGF (2016a).

168 Or through providing exclusivity incentives, such as in Argentina, which has just instituted a 15-year period in which national operators who build last mile broadband networks will not be forced to open them up to third parties, acting as an incentive for incumbent telephony companies. For other examples see http://a4ai.org/affordability-report/report/2015/.

estimates the cost of owning a mobile phone averaged almost 20% of monthly income in 2015[169].

The GSMA estimates that at least 3,000 paying subscribers are necessary to justify the cost in installing a GSM base station.[170] With traditional mobile operators now reaching the limits of their markets, the growth in uptake of mobile services is also slowing down– the GSMA estimates that annual mobile revenue growth is expected to drop to 2% by 2020.[171]

Telecom economists such as Richard Thanki have concluded that to connect the next two billion people on the planet with the lowest income levels, services will need to cost less than USD 4.50 per month.[172] In rural developing country settings with dispersed populations, these revenue levels are likely to be inadequate to provide sufficient return on investment for a national mobile operator burdened by the fixed costs inherent in their technology and business models. In Brazil, for example, there are locations where rural mobile base stations have been set up only to be abandoned by operators due to lack of sufficient revenue generation.

As a result of growing awareness of the limitations in the national mobile operator model, there is increasing interest in exploring alternative strategies for reaching the unconnected. Innovations in low-cost communication technology have created new possibilities for the development of affordable, locally owned and managed communication infrastructure. As a result, a growing number of communities and small local operators have taken a more pragmatic approach, using off-the-shelf low-cost commodity networking equipment to provide themselves and others with WiFi, GSM and fibre connections. In some cases these networks are now connecting thousands of people and there are increasing indications that community-based infrastructure building models

169 See International Telecommunication Union (2015).

170 IGF (2016b).

171 See GSMA (2016).

172 See http://dynamicspectrumalliance.org/wp-content/uploads/2016/05/New-Developments-in-Spectrum-Sharing RichardThanki.pdf

could provide a viable alternative. For example, Rhizomatica is helping remote communities in Mexico gain access to voice services for about USD 3.00/month[173] and a broadband connection could be supplied for little more. Aside from simply providing affordable access, these community driven initiatives also have the potential to result in important benefits, not only in terms of the improved potential for local development resulting from better access to communications, but also as a result of the process of collaboration and group decision making in setting up the service.

However innovative bottom-up initiatives are still relatively rare, and may be dependent on a unique opportunity or special set of circumstances. They also often face overwhelming regulatory and financial hurdles, or require technical, economic and regulatory support to meet scaling and sustainability challenges. Being geographically dispersed and unconnected to one another they are also hard pressed to exchange experiences and learning systematically, which makes facing these challenges even more difficult.

5.2 Background

The initial steps in building a body of knowledge and an understanding of the technical, social, economic and institutional dynamics in this area actually began decades ago, before the emergence of the commercial internet, when many of organisations deployed their own infrastructure to establish networks for their particular communities, and many linked them globally[174], either through direct dial phone calls, or through the X.25 packet switching network. In the intervening years, innovative use of radio spectrum and wireless network technology capacity building[175], has led, for example to nine of APC's members[176] being active in supporting the development of community-built communications

173 Lakhani (2016).

174 See Murphy ([s.d.]).

175 See http://www.apc.org/en/project/open-access-spectrum-development.

176 AlterMundi, Colnodo, Digital Empowerment Foundation (DEF), Fantsuam Foundation, Guifi.net, Nupef, Pangea, Rhizomatica, Zenzeleni Networks.

infrastructure across Latin America, Africa and Asia. This presents an important opportunity to gain from their experience, which can be augmented by the close relationships APC has with other partners supporting work in this area.

With the growing recent interest[177] in alternative connectivity models over the last 18 months, a number of workshops on community-based networks have recently taken place, such as those at the last two IGFs, and at the Dynamic Spectrum Alliance summit in Bogota in 2016. In addition, the GoLocal! workshop was organised by Rhizomatica at the University of California-Berkeley in December of 2014.[178] These workshops brought together lawyers, policy experts, technologists, entrepreneurs, community organisers, and researchers to discuss how to increase the viability of community and locally owned telecommunication infrastructure. Earlier experience and the discussions at these events indicates that there appears to be significant potential in community based solutions, not only for providing better connectivity, but also in supporting local economic development and social inclusion more broadly. However, for these initiatives to be expanded and the approach 'mainstreamed', two key questions need to be fully answered:

1 Are community-based infrastructure deployment models a viable and universal solution to meeting gaps in the current national infrastructure deployments? And if so, what are the circumstances that make them successful?

2 What are the additional benefits to the local community in terms of well-being, gender equity and social and economic development when local connectivity initiatives are locally owned and operated?

A potential strategy for answering these questions is outlined below.

177 See for example Connecting the Next Four Billion: Strengthening the Global Response for Universal Internet Access, a February 2017 USAID report by SSG Advisors which concludes that mobile broadband is not sufficient and different technology and business models will be required to meet the connectivity needs of those at the bottom of the pyramid. See https://www.usaid.gov/documents/15396/connecting-next-four-billion.

178 See http://decentralizethis.org/Go_Local!_Workshop

5.3 Conceptual and Theoretical Framework

In order to provide a more systematic look at the environment where local connectivity initiatives take place, the concept of the ICT ecosystem has particular value here. As outlined by community networking researchers at the University of the Western Cape (UWC):

The use of ecological metaphors to describe complex systems has grown over the past two decades, and this terminology has been linked to Moore's suggestion that businesses operate in symbiotic relationships with one another, with their customers and with other economic actors[179]. If this proposition is appropriate for local connectivity initiatives, then as with any ecosystem, we might expect that this one would comprise many mutually interacting parts, heterogeneous in their arrangement and characterised by interdependence.[180] These components are arranged in sub-systems, each with their own networks and dynamics.[181] At the least, the communications infrastructure ecosystem comprises technology; policy and regulation, along with the institutional set-up for the deployment and maintenance of equipment; and the relationship with the end-user.[182]

As further outlined by the UWC, the model presented by Fransman[183] can help in the analysis of the different components of this ecosystem:

Apart from the four groups of players described in the model – network element providers, network operators, content and application providers, and final consumers, to whom we will refer as end-users – Fransman also includes institutions and organisations in the environment where those players interact. Institutions described are those who 'shape the rules of the game according to which the players interact and influence their behaviour' and include standardisation and regulation bodies and

179 Moore (1993).

180 Bertalanffy, L. (1968). General Systems Theory. New York, NY: George Braziller.

181 Saaty & Kearns (1985).

182 See Rey-Moreno (2016).

183 Fransman (2007).

financial markets. Organisations are described as those who 'have the power to change institutions although they themselves are influenced by the institutions they are changing.'[184]

Nevertheless, it is also important to recognise that although some of the ecosystem elements are local, many are not (IXPs, fibre backbone operators, electricity providers, etc.).

While it has become generally recognised that an ecosystem approach is necessary to address the many different causes of access bottlenecks, this needs to be augmented with a methodology for prioritising policy change that takes into account the diversity of conditions within and between different countries. Better knowledge of the different parts of the ecosystem is needed to create the enabling environment necessary for local connectivity initiatives to scale, and for models to be replicated in other areas.

For a pragmatic approach to understanding the dynamics of local infrastructure provision, the key elements of the ecosystem that need to be focussed on are a) the network infrastructure providers, b) the policy and regulatory bodies, and c) the end-users with little or no connectivity. In essence, Fransman's ecosystem model would be changed, so that the end-users become network operators as well, essentially blending (a) and (c), also called 'prosumer' or a form of commons-based peer production. In many aspects, this view is more closely aligned with the ethos and architecture of the Internet than with the traditional telecom services provision model – *i.e.* people don't 'connect to the Internet' or wait for the Internet to come to them, they simply help building it.

The main characteristics of each part of the ecosystem that have a role in local connectivity infrastructure initiatives are described further in the following sections.

5.3.1 Network Operators

Currently the mass provision of communication services to the public in developing countries relies almost entirely on the

184 Fransman (2007).

private/commercial "national provider" model using a single technology suite (2/3/4G, technically known as 3GPP). This model is also associated with a culture of secrecy around what is usually classified as "commercially sensitive" information on the disposition of telecommunications infrastructure, pricing and level of use. The deficiencies with this approach have indirectly led to marginalisation of poor and rural populations, particularly in developing countries, where connectivity may not exist at all, and where coverage does exist, services are generally unaffordable.[185] Examination of alternatives has suffered from the inertia created by lack of information for policy making and by incumbent operators that have a natural resistance to new technology and business models that might undermine the value of their franchise on the market and lower the value of their investments in licensed spectrum and capital-intensive mobile infrastructure.

5.3.2 Policy and Regulatory Bodies

Policy makers and regulators have a vital role to play in the connectivity ecosystem. Unfortunately, ineffective telecommunications regulation could be one of the greatest barriers to connectivity in many parts of the world, especially in the global South, and particularly in remote and rural areas. Generally, policy and regulation is almost entirely focused on large national providers which are rightly (for their shareholders) concentrating most of their network investment in major population centres. While there may be policies that also aim to promote connectivity in underserved locations, these strategies are usually not very well developed, or effectively implemented. It could also be said that underserved areas exist in the first place because of the ineffectiveness of the national provider model in addressing the needs of the marginal user.

In particular, the lack of information and public debate on spectrum assignment and use, as well as the opportunity cost of limited unassigned spectrum and its impact on the unconnected, hamper the ability of local organisations to innovate connectivity solutions and make it difficult for policy makers and regulators to ensure

185 See http://a4ai.org/affordability-report/report/2017/#executive_summary

these projects are supported. In many cases, there is regulatory capture by the mobile operators due to their economic power and the extensive lobbying resources available to them, which explains, in part, the limited awareness of the potential alternatives among policy makers and regulators.

In addition, current mobile and internet coverage maps and statistics do not accurately reflect the number of unserved communities, making it difficult for regulators to meet their mandate in this regard. Most regulators have Universal Service and Access Funds that are often unspent, in part, for these reasons.

5.3.3 End-users as Prosumers

Innovations in low-cost communication technology have created new possibilities for the development of affordable locally owned and managed communication infrastructure in which people have the potential to be both users and producers of the network resources. This is helping to spread the idea that local connectivity models are a viable solution to connectivity issues, and as indicated above, more closely reflects the way the Internet was initially conceived and built.

There are also various intangible benefits that can accrue to a community group through engagement in a common project such as a local access network. Thus, local networks can have a positive impact on community development goals and gender equity. At the same time, it is necessary to be aware of the economic and social issues which may impact heavily on the potential success and role of local networks. For example, social and cultural norms that contribute to the persisting digital gender divide need to be addressed to ensure that women, girls and other marginalised groups can benefit from local networks.[186]

In summary, apart from economic and social issues, there are a range of human capacity and other barriers that may constrain more widespread and better connectivity in marginalised areas. In

186 The Gender and access IGF (2016) Best Practice Forum cites barriers to women's meaningful access which includes affordability, capacity and skills, relevant content and participation as decision-makers in addition to culture and norms.

particular, entrepreneurs and community organisations alike are often inhibited from pursuing these options due to policies that do not embrace the potential of bottom-up innovation. Limitations of these frameworks include: restricted access to spectrum; network and service operation licences that are not geared to underserved areas or to community-level approaches; and lack of affordable access to wholesale backhaul networks and electricity.

5.4 Methodological Framework

To generate the knowledge required to support the development of community-based networks, active engagement can be an effective method to test approaches to creating a more enabling environment for local connectivity initiatives. Thus, we believe the most effective strategy is to take an 'action research approach as the methodological framework to guide work in this area. As explained further below. In addition, a gender analytical framework is necessary to identify approaches and mechanisms that address barriers to participation, limits to roles and overall benefits for women and girls, as well as other marginalised groups.

Thus, to help change the current ICT landscape, analysis needs to focus on four areas:

1. In-depth case study research and analysis
2. Open telecoms data, policy and regulation
3. Awareness raising and movement building
4. Mechanisms to support existing and emerging local connectivity initiatives

As an example of the action research approach, after a needs assessment with a community in Oaxaca, Rhizomatica explored the Mexican regulatory framework and the spectrum assignments and successfully intervened to obtain allocation a set of unused GSM spectrum bands based on the constitutional rights of indigenous people[187]. Since then, Rhizomatica has been working on creating over twenty 2G cellular networks with rural

187 Wade (2015).

communities in Mexico. This has led to increased demand from users for these networks to evolve into 3G and 4G networks. In order to do so, research about how to manage this technological transition is needed. This touches technology, regulation, as well as a way to measure and mitigate the social impacts of such a transition. Additionally, these results need to be documented and disseminated in case other communities around the world want to embark on a similar process.

5.4.1 In-depth Case Studies and Analysis

Existing local network initiatives need to be subjected to rigorous technical and economic analysis using a case study approach, selecting initiatives based on opportunities to gain access to in-depth data, with a spread of different demographic, economic, technology and institutional settings. Entrepreneurially driven small-scale networks and other local connectivity initiatives that are not necessarily community-driven, but serve rural areas affordably, could also be included to better understand the dynamics behind the adoption of these different approaches. Selection criteria should also focus on initiatives that have been operating local access networks for a significant amount of time in order to ensure that a sufficient level of experience in each case can be analysed to provide the necessary data. Case studies would likely involve initial site visits and in-depth interviews with the stakeholders in local connectivity projects to gather the necessary data, including demographic, gender and social impact information, network investment and use, user profiles, technical design and equipment track records, etc.

The information obtained can be used to provide an objective comparative analysis of the economic viability of the different models for deploying local access infrastructure. The real-world examples and knowledge gained can then feed into the awareness-raising and capacity-building activities, described below, as well as for dissemination in various national and regional policy-making and development assistance forums.

5.4.2 Open Telecom Data, Policy and Regulation

It is necessary to identify favourable policies and regulations that could support local connectivity initiatives, as well as the barriers and challenges in the regulatory and policy space that make it difficult for these initiatives to flourish or even exist at all. This would identify the laws and regulations at different levels, and where the law might provide opportunities for local initiatives, but also how policy makers and regulators think and act towards them. We believe it is possible to foster a regulatory culture that values openness and understands the potential for local connectivity initiatives to help meet universal access goals, but it is also necessary to understand how to bring this about. In this respect, identification of the possible policy and regulatory levers that already exist is particularly important, because in many cases there may be existing language in the constitution or telecom laws that are not being brought to bear on how actual regulations could be implemented to support local connectivity initiatives.

In addition, advocates for local access, as well as policy makers and regulators, need tools and resources to create effective local access strategies. A necessary stepping-stone in this process is transparency in data on existing and planned network infrastructure: from fibre optic network ownership, routes and technical specifications, to tower heights and locations, to wireless spectrum assignments. Lack of information and transparency makes it impossible for all actors, including civil society, the research community and the private sector, to engage in solution-oriented dialogue with policy makers and regulators.

Good practice acquired from open data initiatives to engage both sector and open government data advocates in making telecom data publicly available is required here, as part of a coordinated effort to ensure that telecom infrastructure data is gathered, systematised and made easily accessible for all. Areas of particular need include:

- Maps or ideally GPS co-ordinates of terrestrial fibre optic network routes and plans, points of presence, cable characteristics and ownership.

- Terms on which telecom infrastructure (towers, fibre, capacity, etc.) is available to smaller operators.
- Location, characteristics (height, access to shared power, etc.) and ownership of tower infrastructure.
- Wireless spectrum occupancy, frequency assignments, license terms, and fees.
- Public pricing rate cards for access to basic infrastructure such as undersea and terrestrial fibre and microwave networks.

5.4.3 Awareness Raising and Movement Building

Relatively few local communities know that it is actually possible to set up local infrastructure that provides access to communications and information. If local access is to be more widely accepted as a viable alternative, a broader and more systematic approach to awareness raising and movement building is necessary. In this respect good practices need to be identified and generalised in order to support local connectivity initiatives in underserved communities more widely throughout the global South. In particular, an understanding of the requirements for technical, management and administrative skills to deploy and sustain networks is necessary so that these can be developed with appropriate support mechanisms. Similarly, once awareness grows, also needed is to ensure that those involved in local access initiatives have the most effective training materials and other capacity-building resources, including to knowledge of mechanisms to include gender components in projects.

By addressing these aspects, it is expected that a cohesive movement of local access practitioners can be built that can provide support to new and emerging networks. This is also of particular concern to various national and international networks, which are active in communities with little connectivity. A number of global and regional organisations have networks on the ground are likely to provide impetus for local connectivity projects, and could support potential local connectivity opportunities related to their particular constituency, particularly libraries, community radio stations, and public access points, in which the congruencies with local access networks are particularly strong.

5.4.4 Support for Existing and Emerging Local Connectivity Initiatives

A number of existing local connectivity initiatives, as well as emerging/new initiatives, could be supported with innovative interventions to push the boundaries of what community networks and local connectivity initiatives can become. Fostering this "living laboratory" will help to integrate the activities described above, to test the conclusions and to better understand: the technological needs that innovation requires at this level; creative, replicable ways to sustain these networks; the possible interaction among different community networking projects working on various aspects; and the policy and regulatory implications of these new and potential network forms.

Related to direct interventions, research needs to be conducted on emerging technologies and sustainability models that could benefit the local connectivity space, particularly in the developing world. This can be complemented by exploring industry trends, for example in mobile broadband and dynamic spectrum assignment technologies, as well as ground-breaking local initiatives in more developed nations, such as around community optical fibre.

5.5 Conclusions & Outlook

This is not expected to be an exhaustive list of requirements for research and activities in this area. It is likely that methodologies and action research activities will need to be refined and adjusted as results come in. In this respect, the outcomes of the research described above would provide a first cut at reaching a better understanding of the dynamics of community based solutions to local access infrastructure. New areas for further research will likely emerge, and new methods will likely be required.

Given the huge potential demand, a number of scaling and replication, innovative awareness raising activities are likely to be needed to reach more countries and the hundreds of thousands of unconnected villages and communities around the world. In that sense, the authors, would like to invite other individuals and interested organisations to constructively criticize and contribute to the agenda described above, so that the meagre resources available can be leveraged to create the enabling environment for a vibrant community network movement around the world, as envisioned by the UN IGF Dynamic Coalition on Community Connectivity (DC3).

5.6 References

APC (2007). "The sky's the limit: new wireless connection record - 382 kilometres", *Associatio for progressive communications*, 2007. Available at https://www.apc.org/en/news/wireless/lac/sky-s-limit-new-wireless-connection-record-382-kil.

Fransman, M. (2007). "Innovation in the new ICT ecosystem" *Communication & Strategies, 68* (4), 89–110.

GSMA (2016). "Global mobile trends". 2016. Available at https://www.gsmaintelligence.com/research/?file=357f1541c77358e61787fac35259dc92&download.

IGF (2016a). "Overcoming Barriers to Enable Women's Meaningful internet access". Available at http://www.intgovforum.org/multilingual/index.php?q=filedepot_download/3406/437.

IGF (2016b). "Policy options for connecting & enabling the next billion(s)". 2016. Available at http://www.intgovforum.org/multilingual/index.php?q=filedepot_download/3416/412.

International Telecommunication Union (2015). "Measuring the Information Society Report". 2015. Available at http://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2015/MISR2015-w5.pdf

Lakhani, N. (2016). 'It feels like a gift': mobile phone co-op transforms rural Mexican community, *The Guardian*, 2016. Available at https://www.theguardian.com/world/2016/aug/15/mexico-mobile-phone-network-indigenous-community.

Moore, J. F. (1993). "Predators and prey: A new ecology of competition". *Harvard Business Review, 71* (3), 75–83.

Murphy, B. M. ([s.d.]). "The founding of APC: Coincidences and logical steps in global civil society networking", *Association Progressive Communications*, [s.d]. Available at https://www.apc.org/en/about/history/coincidences-and-logical-steps-in-networking.

Rey-Moreno, C. *et al.* (2016). "An in-depth study of the ICT ecosystem in a South African rural community: unveiling expenditure and communication patterns", *Information Technology for Development*, vol. 22, 2016. Available at http://www.tandfonline.com/doi/full/10.1080/02681102.2016.1155145?scroll=top&needAccess=true.

Saaty, T. L., & Kearns, K. P. (1985). "Analytical planning: The organisation of systems, international series in modern applied mathematics and computer science". Oxford: Pergamon Press, 1985.

Wade, L. "Where cellular networks don't exist, people are building their own", *Wired*, Jan. 2015. Available at http://www.wired.com/2015/01/diy-cellular-phone-networks-mexico/.

World Bank Group (2016). "Digital Dividends", 2016. Available at http://documents.worldbank.org/curated/en/896971468194972881/pdf/102725-PUB-Replacement-PUBLIC.pdf.

6 The Success of Community Mobile Telephony in Mexico and its Plausibility as an Alternative to Connect the Next Billion

Erick Huerta, Peter Bloom and *Karla Velasco*

Abstract

This paper introduces a framework for the design and instrumentation of Community Mobile Telephony (CMT) from a Mexican perspective but applicable to other regions. Particularly, this paper describes the case of Telecomunicaciones Indigenas Comunitarias A.C.188 and Rhizomatica whose CMT network began operating in 2013 in Talea de Castro, Oaxaca, under a private network scheme and using a segment of spectrum, acquired for free for non-profit use. This case demonstrates that under a new technical, economic and organisational scheme, it was possible to offer, in a sustainable manner, mobile services in commercially unfeasible localities.

By 2016, the system covered eighteen localities of between two hundred and three thousand inhabitants. This confirmed not only the viability of the model but also its expansion potential to communities without mobile service. Moreover, it paved the way for the creation of a new framework among traditional operators which allowed them to connect rural locations, previously deemed inviable. The success of the project has given way to a new legal framework and a modification in spectrum administration, which, for the first time in history, assigned a portion of GSM spectrum for social purposes.

This paper proves with the success of the Mexican case that Community Mobile Telephony is a plausible alternative to connect the unconnected, by supporting communities to build and maintain self-governed and owned communication infrastructure.

188 Through this article, *Telecomunicaciones Indígenas Comunitarias A.C.* will be referred to as TIC A.C.

6.1 Introduction

This document is an adapted version of the "*Manual de Telefonía Celular Comunitaria: Conectando al Siguiente Billón*" written by Erick Huerta and Peter Bloom. The *Manual* is directed to policy makers, social entrepreneurs and communities interested in implementing the Community Mobile Telephony framework to meet the communication needs of populations in remote and isolated areas. This work is the result of two years of research and the systematisation of various experiences. Over this period, essential elements of the Community Mobile Telephony model were identified in order to elaborate recommendations encouraging the replication of the model in other regions of Mexico as well as in other countries.

This chapter is based on the empirical work and research mentioned above and is organised as follows:

- **a** An introduction to the concept of Community Mobile Telephony in the context of Rhizomatica and Telecomunicaciones Indigenas Comunitarias (TIC A.C.) and their successful case in Mexico;
- **b** A breakdown of characteristics of the communities and resources that comprise this type of Community Network (CN);
- **c** A description of the general structure and legal framework of the CN;
- **d** An explanation of its technological, economic and organisational aspects;
- **e** A conclusion and presentation of current challenges.

6.2 What is Community Mobile Telephony?

The Recommendations for the Development of Information and Communication Technologies (ICT) in Rural and Indigenous Communities of the International Telecommunications Union (ITU 2010) indicate that, to provide services for remote and unserved localities, system operation must be performed taking into consideration the organisational form of local economies.[189] Importantly, this should be done by establishing a chain of

189 This is based upon a tripartite theory of economics developed by Braudel, which is explained later in the article. The theory identifies three economical levels: subsistence, local and global. For a more detailed research on the subject, see Özveren (2005).

operators whose roles are related to the core competency areas in which they are most effective.

The model of Community Mobile Telephony is based on the establishment of a local network, which is completely operated and managed by the community, and supported by a cooperative association to which all participating communities belong. Long-distance or off-net calls are made using the Internet, access to which is provided by a small Wireless ISP, while the Voice over IP service is provided by a small operator. This arrangement gives rise to a win-win situation, where the community participates in the operation of the network and the users of the network benefit from lower costs, ensuring the income from this operation remains within the community, and shared with an association (TIC A.C) to which the CN belongs, that can invest profits in innovation and training.

Importantly, the communities are the owners and the operators of the local cellular network infrastructure. Together with TIC A.C. the community builds and manages the network through the installation of a cellular transceiver and the necessary equipment for its administration.

6.2.1 Elements of the Model

Community Mobile Telephony is based upon four essential elements:

1. **Organisational Base:** the social support which allows the community to operate a network through a community-based approach. This social grounding also allows many communities to manage a concession/license and provide maintenance services and personnel training.
2. **Technological Base:** identifying the right technology for the communities and their organisations, one which is affordable in terms of price, maintenance and operating costs.
3. **Economic Base:** a business plan based on service unbundling according to economies of scale, which allows the communities to provide the service at a low cost.
4. **Techno-Economic Base:** the material and human resources infrastructure that form the basis for the community to acquire the necessary skills for operating the service, as well as for the maintenance and development of applications and innovation.

6.2.2 Legal Framework

The legal model comprises the implementation of internal regulations (self-regulations established by affected individuals) as well as the application of external regulations (laws and regulations). Therefore, the model answers two important questions: 1) how does the system self-regulate, and 2) what current regulations are applicable?

Before answering these two questions, we began by analysing the essential characteristics of the project and of the subjects being regulated, *i.e.* indigenous communities, hacker communities and telecommunication networks.

6.2.3 Characteristics of the Communities Composing the System and of the Resources Comprising the Network

The system is the result of two organisational components that are articulated to create a telecommunication network. Thus, for its regulation, it is essential to understand the guidelines and principles upon which these components function and interact. It is also important to know the functioning principles that derive from the kind of resource in question, in this case telecommunication and information networks. The organisational components that create this network are:

- Indigenous communities
- Hacker communities

The question that arises is: which laws and regulations govern these entities and networks? This question will be explored in the following sections.

6.2.3.1 Indigenous Communities

It must be noted that the CN model analysed in this paper exists in indigenous communities of a certain region, and that these communities, while sharing some characteristics with other communities in Mexico and the world, are unique in some important ways. This must be taken into account when adapting the model to other regions with different forms of local organisation.

The first particular feature characterising the Mexican communities of The Sierra Juarez, in Oaxaca, is that private property is almost inexistent. Most of land is communal and decisions regarding its use are made by an assembly of co-owners or "*comuneros*" integrated by the heads of the household of the agrarian community (Bloom, 2015).

Municipalities enjoy the benefits of autonomy and most are governed by "*usos y costumbres*", an indigenous customary law system of community service (Bloom 2015) which is the basis for electing community authorities. This means that municipal presidents, as well as the town councillors, are elected by a community assembly, and occupy their role for a year or so with no financial remuneration.

Each community has an independent normative system, and its particularities are reflected in the way each elects its authorities, but also in how they manage services and resources like water, roads and education, and even in the way they celebrate. Therefore, these communities have nearly full autonomy regarding their systems of government and concerning the management of their resources.

Looking closely at the characteristics of these indigenous communities we can identify the following principles:

- a **Autonomy**: The capacity of self-governance and to make decisions regarding development. The highest authority for these decisions is the Assembly.
- b **Key Positions of Elected Authority**: It is comprised of leadership assignments based on service —with no remuneration— that extend for short periods of around one year and a half at the most.
- c **Commonly Held Resources:** the land and the territory are considered a common good that cannot be appropriated and thus, cannot become a source of personal enrichment.

The way these communities view the world has had an influence on what has been called by indigenous thinkers themselves *comunalidad*, which, according to Floriberto Díaz is expressed as: "The earth as a mother and as territory, the consensus of the Assembly for decision making, unpaid public service as an exercise in authority, collective work as an act of recreation and rites and ceremonies as an expression of the communal gift" (Díaz in Rendón 2003).

These are the principles that govern daily life in the communities in which these networks are developed. These principles are expressed in various ways in the processes of design, installation and operation, and in legal terms are reflected in the regulations concerning the ownership of the network, contractual relationships and rights regarding resources.

6.2.4 Hacker Communities

The technology upon which this network is based is primarily the result of two free software projects that were able to reverse engineer and re-encode GSM's closed source technology in order to make it available as an open source technology (OpenBSC and OpenBTS).

Interestingly, the hacker and developer communities[190] that have managed to develop these projects are governed by principles which are compatible with the regulation systems applied in the context of common resource governance, and which have been practised ancestrally by indigenous communities (Laval & Dardot 2015). According to Laval and Dardot (2015:195), hacker ethics is based on "a certain happiness *ethos*, and on a commitment to freedom, and is part of a relationship with the community intended for common benefit."

One definition of "hackers" follows:

> People that enthusiastically dedicate themselves to programming and believe that making information part of a common good is their ethical duty so they share their skills and expertise by distributing free software and by allowing access – whenever possible – to information and resources related to computer science (Himanem 2001:5).

The consideration of work as pleasure and knowledge as a common good are principles completely compatible with the concept of *comunalidad*, and, as Laval & Dardot (2015) rightly remark, "hacker ethics play a role similar to that of the collective regulations that govern the institutions which are the basis of common natural goods [shared by the community]".

190 The term hacker should not only be applied to the information or computer hacker. The hacker is an enthusiast-expert of any kind (Himanem, 2001:6).

In an effort to identify some of the principles that emanate from the abovementioned ethical approach, we can identify the following elements:

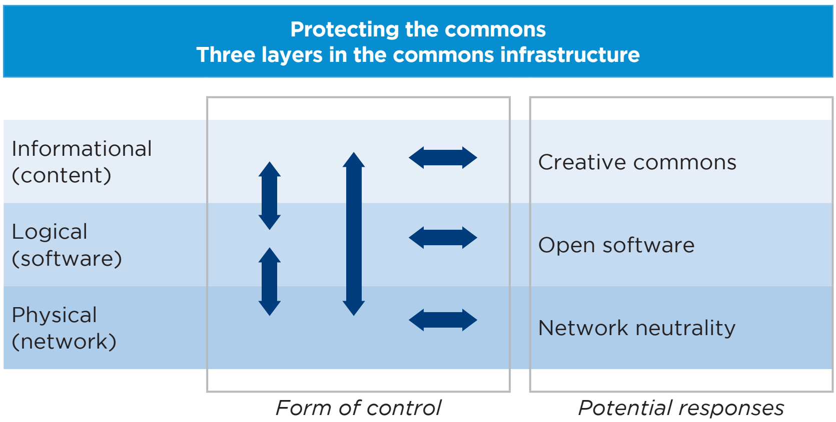
- **a Creative play:** work is considered a creative act that is performed out for fun and passion, not due to an obligation or for money; it is carried out collectively.
- **b Solidarity:** creation is carried out through a process of mutual assistance, whose only objective is to contribute to the things being built.
- **c Common goods:** the goods shared by the community are considered common to all, not subjected to ownership, and as a consequence, they must remain available for everyone to modify since there is value in keeping them away from private and public control (Lessig, 2001).
- **d Constitutional and operative regulations:** openness and collectivity imply the establishment of a series of constitutional regulations and operative processes as well as instances for the resolution of conflicts.

6.3 Networks and Spectrum

The definition of a **common good** concerns not only the particular characteristics of the common good or resource, but with the way the community establishes relationships with it. If we are to consider networks and the electromagnetic spectrum as common goods, we must analyse both aspects.

A common good is one whose access must be allowed to anyone who meets certain requirements. It is in this context that both the spectrum and public telecommunication networks are considered common goods.

Since the means of communication are the subject of this analysis, we will refer to the layer model delineated by Professor Yochai Benkler (Lessig 2001:23). According to this model there are three different layers in any communication framework. The first one is a *physical* layer: it refers to the physical medium through which data travels, which is to say cables or spectrum. The second layer is the *logical* layer or *the code*, which refers to the software programs that allow the operation of the physical infrastructure. The last layer, the informational layer, refers to the *content,* that is to say, what is being said. According to this network structure, each layer can be open or introduce restrictions, as the following table exemplifies:



Source: Umemoto (2006).

Let us analyse now the composition of the self-managed telecommunication system and how these three layers can be structured to see if they correspond to a free and open scheme or to a controlled one.

6.3.1 Physical Layer (The Network)

The structure at hand is a hybrid, comprised of three distinct networks:

1 A local cellular CN consisting of a transceiver owned by the community and a part of the spectrum in the 850Mhz band granted to an association (similar to a cooperative) to which the community belongs, in this case TIC A.C.

2 A transport network comprised of a system of WiFi links. The links belong to a regional ISP but the spectrum is unlicensed. There are plans to migrate to the 10GHz band that will be granted as secondary use to the association that will allow its free use for coverage purposes. In this approach, the links will be part of the ISP but the spectrum will be granted to the association (in the case of licensed spectrum).

3 Finally, the ISP is connected to a network backbone (fibre optic) of a public telecommunication network.

We will now analyse these segments to determine if they are free or controlled:

Segment	Characteristics
Local Network	(850Mhz Spectrum) Free and open commons: At first, any community interested in becoming an operator of the system using their own normative systems can access this technology.
Transport network	(WiFi or 10GHz Spectrum) Free and open commons: anyone can access this segment and it will remain so for the 10Ghz as long as its use is intended for rural communities.
Network Backbone	Restricted: In this case a fee for an operator with substantial market power is required. However, access could be unrestricted and free* if there was an optical fibre installation available.

*By "free" we mean that the project considers only costs. Contributions are solely for the sustainability of the common good.

It is important to point out that we are detailing only the general characteristics, since the functioning of the network is complex and implies both controlled and open elements. For instance, even though the local network is free and open, it does not interconnect directly with other license holders or mobile carriers, given there are matters of cost that might render the provision of the service inviable. Nevertheless, this restriction does not imply that the network is a closed one.

6.3.2 Logic or Code

The local segment operates with free and open source software. With regards to the transport network, this CN model refers to the Internet, which can be considered an open network, given the end-to-end protocol and the fact it is delivered with unlicensed spectrum. The network backbone, on the other hand, normally operates with closed source code and hardware, and the same happens with the interconnection to the telephone network

(PSTN). According to the network structure previously described, the model's proposition is a commons-based structure in almost all its segments and looks like this:

Informational (content)	Creative commons
Logical (software)	Free Software
Physical (network)	Free open and neutral in two of its segments with a closed network backbone

6.3.3 Information

At first glance all the information flowing through the network is free, although regulations establish certain restrictions for instance regarding blocking and take down of specific content, which can be deemed as illegal. To specify the different scenarios regarding information restrictions we must turn to the architecture of the community telephony network itself, which is comprised of three kinds of networks and implies a different legal system depending on the type of governance applied to each network.

The indigenous communities that own and operate the networks are governed by the regulation system of their own territories and by their own authorities, according to Article 2 of the Mexican Constitution, while the other elements of the network are subject to the application of Mexico's legal system.

The way in which the CNs are configured ensures privacy regarding personal information, but also access to it, when in accordance with the required regulatory systems.

6.4 General Structure and Legal Framework

As it must be clear by now, the system is not based on a centralised structure. Each part is completely independent and is able to operate independently. However, there are collaborative relationships that allow the whole network to function better. Like the *rhizome*[191], each element becomes itself a root from which many different organisations might sprout. The local network is independent and can operate by itself and the same rationale applies to the organisation and the transport network.

Each part of the system has its own constitutive regulations and its own form of governance, and there is a general governance structure when the communities operate in conjunction. Each constitutive and governance structure is backed up by a legal framework or by an applicable regulatory system.

6.4.1 The Local Network

The legal framework in which the local network is inscribed corresponds to the regulation system of each community. In Mexico, according to Article 2 of the Mexican Constitution and based on Agreement 169 of the ILO (International Labour Organisation), indigenous peoples and communities have the right to preserve and develop their ways of organisation and their regulation systems, which are absolutely valid and applicable within their territories.

Currently, in most countries' telecommunications regulations, a distinction is made between private and public telecommunication networks and private networks are usually conceived for private or experimental communication and do not require an operation license unless they use licensed spectrum or are intended for commercial purposes.

Even if there is a specific regulation for community or indigenous networks as is the case of Mexico, the network architecture considers the local network a private network owned by the community, since it is not a commercial operation and it is circumscribed to a specific territoriality whose owners are the network operators. The network is intended to self-provide services and its interconnection depends on a different network.

191 The *Rhizome* is a philosophical model, which is based on the structure of certain plants that share common features. Notably, it encompasses four different principles coined by Deleuze and Guattari (2009): connection and heterogeneity, multiplicity, a signifying rupture, and cartography and decalcomania.

As we can see, the *constitutive regulations* are derived from the internal regulation systems of each community. This means that community norms will determine the processes upon which the local network shall be established. In most of the communities in Oaxaca in which this system is being developed, the highest authority is the community assembly. The assembly determines the appropriate communication system, the people in charge of setting it up, the obligations of citizens concerning the system and the way the service will be managed. Consequently, the elements that comprise the network are commonly held by the community and are not subject to individual ownership, unless the community itself decides to disassociate them from the common pool.

The governance system is simple. A local administrator holds his or her position temporarily and must answer to the town council and assembly directly. In most cases, the head of the town council carries out his or her job without payment and any potential problems emerging with regard to the system administration are discussed and resolved by the assembly.

6.4.2 The Transport Network

The transport network usually consists of a small commercial operator – which can be a natural person or an entity – that brings Internet service to the communities through a series of wireless links. The legal framework to which this network is subjected is the national telecommunications legislation and regulation. In the case of Mexico these small ISPs may be license holders or registered resellers.

It may be the case that these operators use transport frequencies granted to the Association, which is to say to the communities of which it is comprised. In this case, the governance regulations for these frequencies are related to the internal regulatory system of the organisation and to the regulation systems of the communities that belong to it, this being the case as long as they do not transgress the nature of the concession and remain a not-for-profit social concern.

6.4.3 The Governance Committee

The governance of common goods has to be defined in a very specific fashion, when considering if the good is a rivalrous good or not. It has always been said that the spectrum is rivalrous, a term which refers to a finite good whose consumption by one consumer prevents simultaneous consumption by other consumers. However, this status is not derived from the characteristics of the spectrum itself, but from the type of equipment used (Peralta 2011). Using intelligent systems[192], spectrum capacity can be improved, although it could still present moments of saturation at peak usage times, so it is safe to say that, theoretically, spectrum has the possibility of being used by many with no interference whatsoever (Peralta 2011).

Regardless of our consideration of spectrum as a rivalrous good or not, we still need an organisational scheme, or a governance system. In the model described in this paper, the governance of the spectrum is carried out through a civic association, but it could be assigned to a different kind of organisation with the mission to collectively manage and use this common good, or even to an automated system.

In the case of Community Mobile Telephony, the association constituted for its governance has two common goods under its care: the spectrum itself and the knowledge regarding the technology based on which it can be operated. Since both are considered common goods, they are not subjected to ownership and are open access.

The constitutive bylaws of the association are mainly derived from the consensus among the actors involved in the operation of the scheme; in this case, indigenous communities and hackers. Therefore, there are four types of partners involved in the model:

- **Technicians:** people who share their knowledge regarding technology;
- **Operators:** the communities which are tasked with the management of each local network;
- **Pre-operators:** communities interested in becoming operators;
- **Allies:** people willing to contribute to the project in different ways.

192 Note for instance WiFi networks, which can operate using the same spectrum simultaneously without interfering with each other.

The only requirement to incorporate a community into the Association is that the new community expresses its interest in becoming an operator and that it commits itself to fulfil the mutual collaboration and network administration obligations. The very expression of that interest implies that the regulations of each community must be fulfilled in a consensual manner. In most of the communities in the Sierra Juárez of Oaxaca, this consent is expressed by means of an assembly and by the appointment of a committee.

In other words, the constitutive regulations of the system are the result of an agreement between different parties that leads to an organisational base. In this case, there is an implicit offer for more communities to join the Association which grows stronger when the community approves the decision of being part of the project and commits itself to participate in the governance system.

This agreement entitles the association to request – on behalf of the actual and potential member communities – a social-indigenous license for a frequency band for the mobile telephony system. This concession is granted with regard to a specific area in which the potential communities are located. As new communities become integrated, the association notifies the Federal telecommunications Authority (*Instituto Federal de Telecomunicaciones*) of their incorporation, which implies their use of the spectrum band in that locality or group of localities.

Given the fact that these are local networks, their governance is undertaken by the local community. Each locality determines its own usage of the network, as long as it is compatible with the obligations that each community must meet as members of the Association. For instance, a community may establish a given fee for the service as long as it is enough to cover the maintenance fee charged by the association *per* user.

Importantly, the staff of the association handle decisions regarding issues beyond the competence of each local community, such as interference and roaming. If these latter problems go beyond technical issues, they are dealt with by the Coordination Council, which integrates representatives from both the technical and operational partners. If the cannot be properly handled by these instances, the question is discussed and solved by the Assembly.

The main sanctioning mechanism for operations is the cessation of service and temporal or definitive suspension of rights.

6.4.4 Types of Law and Applicable Law

The CN is mostly a self-regulated system, since it is controlled and operated by the users themselves. The legal regime which it needs to abide to is minimal. Mexican legislation established a favourable regime for CNs, since it makes available a specific license for social purposes. An ideal legal regime would include a specific license for social and not-for-profit operators, as well as appropriate national legislation in concordance with relevant international-law instruments, such as ILO Agreement 169 and the United Nations Declaration on the Rights of Indigenous People. However, a legal framework recognising the rights of indigenous peoples according to international law combined with the utilisation of private licenses could also represent an effective solution.

Another relevant element is the definition of an allocation regime with no economic barriers for the use of frequencies by social or community operators. This implies avoiding exorbitant costs for the assignment of frequencies so that small community operators may have access to them. In other words, the allocation regime should simply comply with Article 13, paragraph 3, of the American Convention on Human Rights, according to which:

> It is essential that the assignment processes for licenses or for frequencies to be open, public and transparent. They must be subjected to clear and previously established regulations and they should imply strictly necessary, fair and equal requirements. In this process, it is important to ensure that there are no unreasonable obstacles or unfair access conditions to the media. The assignment, suspension or non-renewal of frequencies on the basis of discrimination or arbitrary considerations should also be avoided.[193]

193 See OAS (2010). *Una Agenda Hemisférica para la Defensa de la Libertad de Expresión*.

In Mexico, the Federal Telecommunications and Broadcasting Law (LFTR) has established direct spectrum assignment for these type of media and it has determined two primary uses for the same spectrum band segment: a primary use for social coverage in rural areas and – in case it is required – a commercial use for urban areas (*Instituto Federal de Telecomunicaciones* 2016:14). This law has also established a process of assignment by region which considers potential localities where the network will be established. This makes it possible for many social license holders to coexist in one region as long as they concentrate their activities in localities with no coverage.

In this paper, we argue that spectrum use should not generate fees when it is aimed at social use and community or indigenous media. Although there is no general exemption for such purposes, in 2015 the Mexican President presented to the Congress an initiative concerning the matter, which was later approved and which exempts community operators from taxes related to license granting and related to the use of spectrum for research purposes, on the grounds that:

> It has become necessary to approve the present proposition in order to allow said community and indigenous media to fulfil their social goals, and in so doing to contribute to effectively fight inequality in these contexts. This circumstance has been recognised constitutionally and legally as a situation to be avoided.

6.5 Technological Base

Community Mobile Telephony is based on technology having two main characteristics:

- **Low cost:** A total cost which can be covered by marginalised and highly marginalised communities (comprising about 100 families): approximately USD$5,000 or less.
- **Easy to use:** *In situ* operation is reduced to a minimum. Most problems can be remotely managed.

Regarding technological aspects, the Community Mobile Telephony project has been possible due to the development of two technologies: Software Defined Radio (SDR) and GNU Radio.[194] SDR is a radio-communication system in which many hardware components (mixers, filters, modulators, demodulators, detectors, etc.) are executed using software and a personal computer or any other embedded computer. Even though the concept of SDR is not new, recent evolution in terms of digital technology has made it possible, from a practical point of view, to carry out many of the processes that were previously only theoretically possible.

Thanks to SDR much of the signal processing is carried out using general purpose processors, instead of using specifically designed hardware. This allows for changing the protocols and waveforms simply by changing software parameters. It is envisioned that, in the long term, Software Defined Radio will become the dominant technology in terms of radio-communication. This favours the development of cognitive radio.[195]

A basic SDR can be comprised of a computer equipped with a sound card or any other analogue to digital converter, preceded by a radiofrequency adapter. On the other hand, GNU Radio is a tool or open source software that provides signal-processing blocks for implementing radio systems defined by software. It can be used with low cost RF hardware to create software-defined radios or with no hardware at all in simulations. It is widely used in academic environments and in amateur and commercial contexts as well, since it can provide support for researchers working in mobile communication and radio systems in the real world.

The developments of GNU Radio and SDR gave way to the first experiments using software-implemented cellular technology. This meant that network implementers did not have to rely on patented equipment, which is normally very expensive. From

194 GNU Radio is part of the GNU Project and distributed under the terms of the GNU General Public License.

195 Cognitive Radio is a communication paradigm in which the transmission and reception parameters can vary to deliver their mission more efficiently and without interfering with each other.

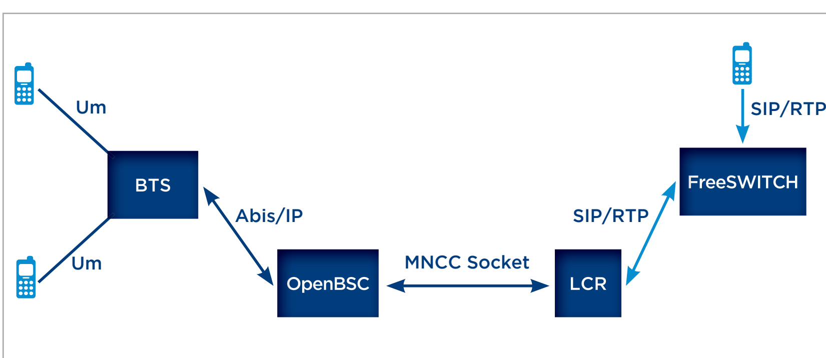
these experiments emerged two important software projects for creating GSM networks: OpenBTS and OpenBSC. The latter is described below.

The implementation of two free software projects for GSM implied the organisation of several experimental processes as well as the inclusion of new and different actors in an environment, which is otherwise very conservative and opaque. These positive changes have had an impact on the total cost for building a GSM system and it has led to the democratisation of the knowledge required to set up a network of this kind.

Before the emergence of the initiatives mentioned above, GSM equipment providers relied on closed source software and, in this context, network operation implied access to specialised information and to equipment, which is hardly available to the public. At present, several innovations make it possible for every individual (not just a telecommunications engineer) to start a GSM network. One only needs to be a free software *aficionado* and being willing and able to handle some basic concepts regarding networking and informatics.

6.6 System Configuration

The next figure provides a general view of the network architecture of the Community Mobile Telephony system. It is important to note that the configuration can vary depending on the conditions and special features of each community.

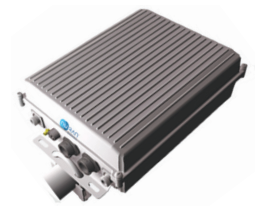


We will now define each of the network components:

A Equipment and Transmission Media

Hardware: Base Station Controller

Base Transceiver Station



WiFi Links

B Software

- **OpenBSC:** Part of the Osmocom project, it is a GSM network-in-the-box software that implements key GSM hardware components such as BSC, MSC and HLR allowing for the operation of a small, self-contained cellular network. In order to connect calls outside the open BSC network, the network works in tandem with LCR to route outgoing calls using the SIP protocol.[196]
- **LCR (Linux Call Router):** An ISDN-based software Private Branch Exchange for Linux.[197]
- **Freeswitch:** An open source scalable telephony platform[198] that was designed to route and interconnect popular communication protocols using audio, video, text or any other media. It also provides a stable telephony platform based on which many telephony applications can be developed using a wide range of free tools.[199]

196 For further information on Osmocom and Open BSB, see http://openbsc.osmocom.org/trac/wiki/OpenBSC

197 See http://linux-call-router.de

198 See https://freeswitch.org/

199 See http://freeswitch.org

- **Kannel:** A compact and very powerful open source WAP and SMS gateway used widely across the globe both for serving trillions of short messages (SMS), WAP Push service indications and mobile Internet connectivity. [200]
- **Custom Software:** There are two software packages designed in their entirety by Rhizomatica. These are:
  - **a RCCN:** This package includes the code that makes all the software components work together. It exposes a REST API (Application Programming Interface).
  - **b Rhizomatica's Administration Interface (RAI):**[201] This is the interface used for managing the network in communities. RAI is a php package that uses the REST API and exposes an administration interface over http that allows administrators to register users, administer payments and send text messages and also enables access to system statistics in real time.

6.7 Economic Base

The economic foundation of this project consists of a business model in which every part of the network can count on the necessary resources for it to be sustainable. Since it is a social endeavour and not a commercial one, it does not seek to maximise profits but rather seeks sustainability. The most essential element is to guarantee that income generated allows for continuity of the service and its improvement.

In this section, we analyse the business model of the Community Mobile Telephony project, which implies looking at the license holder and the operating communities that take part in it. The ISP and the VoIP operator are not taken into account since they are service providers that were already operating independently before the implementation of the model.

For the purpose of this analysis, we will analyse briefly the business model and we will look at a financial evaluation that was designed for the license holder of community telephony operating in Mexico.

200 See http://kannel.org

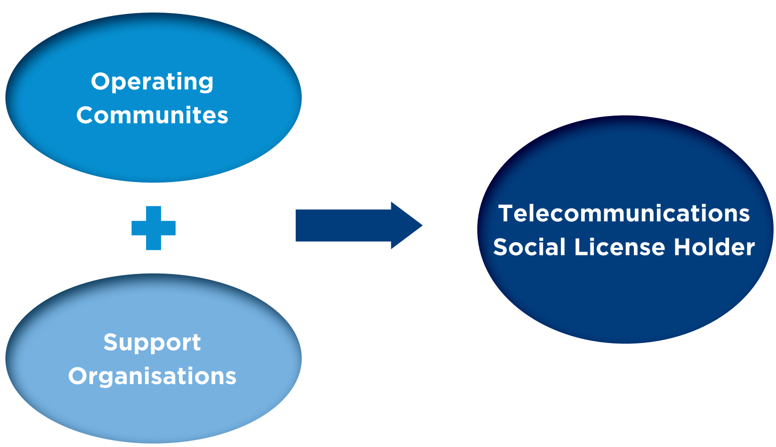
201 See https://wiki.rhizomatica.org/index.php/Setting_up_Administration_computer

6.7.1 The Business Model

Community Mobile Telephony is conceived as a social enterprise. This means that it pursues a social, economic, environmental or cultural mission seeking a public or community benefit. The project provides telecommunication services in order to accomplish this mission, and a substantial part of its income is invested in goods and services that benefit the network.

The entity can be structured as cooperative or as non-governmental organisation, composed of the communities that own the network and the support organisations. These latter organisations contribute to the investment in infrastructure and the operation of the local networks, and the basic technical knowledge regarding maintenance, technological development and administrative and legal advice.

Considering the Social Business Model Canvas (Burket 2010), the following sections detail the components of the social business model on which Community Mobile Telephony operates:



The market segments to which this project pays specific attention are: highly marginalised and indigenous rural communities; communities without telecommunication coverage and high rates of migration to the United States; and communities with 200 to 7000 inhabitants in the Mexican states of Oaxaca, Chiapas, Veracruz and Puebla.

6.7.2 Key Partners

There can be two diverse kinds of key partners. First, those who compose the license holder organisation and, second, those with which alliances must be established in order to operate other segments of the network. In the first group, there are the actors without which it would be impossible to keep the local networks running, while the second group encompasses the entities which are only necessary to provide a supportive outlet to these local networks. The partners can be further categorised into:

- **Operating Communities:** these are partners that invest in the infrastructure of their local network and at the same time operate it;
- **Support Organisations:** these organisations support the network regarding technical, administrative and jurisdictional issues;
- **ISPs:** these are small Internet operators that provide connectivity to the operating communities.
- **VoIP Operators:** they provide the Voice over IP service for outgoing and incoming calls;
- **Other financial associations:** these are organisations that contribute financing for starting projects as they build towards the point of sustainability; they may also provide support for technological development.

6.7.3 Key Activities and Resources

The activities carried out by the license holder and the communities that compose the network are essential for the correct functioning of the CN. For example, the construction of a local network fully operated and managed by the community could not be achieved without the active engagement of and collaboration with key organisations.

Moreover, the establishment of relationships between communities and local/regional stakeholders is vital to encourage development based on complementarity. In this perspective, technological, legal and economic research and development are conducted constantly, in order to improve the operation of the project. Additionally, permanent political and legislative advocacy play a significant role, in order to ensure that the jurisdictional and institutional frameworks allow the operation of community networks.

Key resources in our model refer to the physical, financial and human resources that are required to operate the social license-holding organisation. Essential technical resources are, for example, reception and transmission equipment owned by the communities; open source software; concession for Radio Spectrum; Internet service in each site and Voice over IP service, which is crucial for off-net calls.

With very limited financial resources, the social license-holding organisation is able to deploy the network in each community, including operational and maintenance costs. Human and physical resources take mostly into account social license holder entity staff and offices as well as trained staff working in the communities.

6.7.4 Expenses

The social business model divides the activities carried out by the community from the ones performed by the social license holder. The latter is in charge of providing installation services and all the necessary equipment in order for the communities to operate their own mobile telecommunication network.

It is important to point out that the capital investment for acquiring equipment and installing the network is paid for by the community itself. This network connects to the network of the local ISP so that, in turn, the CN can connect with the Voice over IP service and be able to link outbound and inbounds calls (off-net).

Initial investment is approximately USD $11,000, which includes buying and installing the necessary equipment to operate the telecommunication network. This includes USD $2,000 for installation costs plus the cost of the acquisition of the equipment. Operating expenses include an operator wage of USD $160 per month plus Internet access for USD $80 per month. Monthly cost of the off-net calls via VoIP equals the total of the off-net calls multiplied by the total price of the calls. Moreover, a consultancy and technical service fee of USD $0.80 per subscriber is charged by the association.

Table. Communities Capital Expenses (CAPEX)

Quantity	Concept	Price in USD
1	Telecommunications equipment	$4,950
1	Taxes	$800
1	Import duties and taxes	$1,287
1	Freights	$300
1	Cables, antennas and power source	$650
1	Installation	$2,000
1	Protection against damage	$1,000
	TOTAL	**$10,987**

Source: *Own elaboration.*

Table. Monthly Communities Operating Expenses (OPEX)

Quantity	Concept	Price in USD
1	Half-time salary for staff	$160
1	Internet Access	$80
1	VoIP estimation calls	$250
1	Counselling and technical service	$150
1	Rental, power, water and other expenses	$45
	TOTAL	**$685**

Source: *Own elaboration*

6.7.5 Income Sources[202]

It should be highlighted that there is a distinction made between the community's income and that of the social license holder. The community charges a 40-pesos monthly fee (approximately USD$2.50) to each user for maintenance and operation of its network. From this amount, it keeps 25 pesos and transfers 15 pesos for each registered user to the license holder, to pay for technical and legal services and for assistance regarding the overall operation of the network.

202 This section presents a general view of income resources. The complete financial details are described in *Manual de Telefonía Comunitaria: Conectando al siguiente billón*, section 4.2.

The income generated by every community may be characterised as follows:

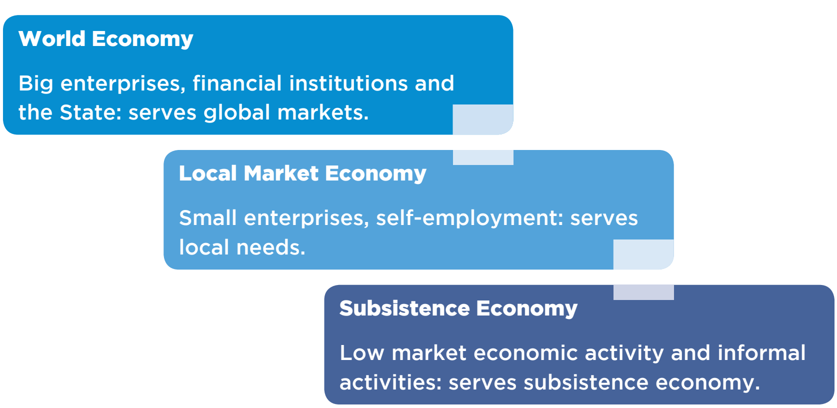
- A 40-pesos fee for each subscriber;
- Income generated by off-net calls = total of the off-net calls X total price of the calls;
- Public subsidies and contributions from the community members migrated abroad.

The income generated by every license holder per state can be characterised as follows:

- Income for installation per community: USD $2,000;
- Advice and technical-service fee of 15 pesos per subscriber in each community in which the service is available;
- Financing and contributions from national and international organisations.

6.8 Organisational Base

In its recommendations for public policies concerning TIC development for indigenous peoples and communities – which are based on the model delineated by Braudel (1980) – the International Telecommunications Union (ITU) establishes that the economy is comprised of three levels, each one capable of fully satisfying all human needs through specific institutions which are suitable for their economic environment (ITU 2013). This model can be expressed graphically as follows:



The ITU document mentions that the most common mistake made in the context of public policies seeking to take telecommunications to rural areas is trying to make companies that operate in the context of a global economy work within a subsistence economy model, which implies the need for large subsidies. In this perspective, the ITU recommends promoting projects based on the architecture proposed above, allowing the network to be operated in each segment or level by the most efficient and appropriate actor.

Community mobile telephony is based precisely on this model: the community operates the local network (subsistence), a regional micro-enterprise provides the connectivity service and a global or national company provides the latter with connection to the backbone network. There is, however, an additional component necessary for the operating communities to be able to work beyond the subsistence level: they require an organisation able to support them in their interactions with other stakeholders at the local and global level. Given the necessary interaction with these levels in the administrative, legal and technological areas, the aforementioned support becomes essential to ensure the sustainability of the networks.

This section explains how the local operators (the communities) – that we have denominated "social license holders" – organise themselves. This organisational model is based on organisedcommunities, which can acquire, manage and operate their networks according to their own community governance system. This section will explore the general structure of the community organisation and to its role. It must be noted that the information presented in this section stems from the Mexican context and that the particular circumstances of this country have greatly influenced the organisational model analysed. However, different countries may present distinct characteristics and, in this perspective, it is particularly relevant to identify the core elements of the local environment to have an understanding of the forms of organisation utilised by the local communities. Such understanding is essential to identify how the local subsistence economy is structured and, at the same time, identify what is the instance or entity that brings the communities together – either formally or informally – in order for them to interact in different contexts. These different contexts may imply cooperatives, public/private associations, chambers of commerce and any other instances that allow the participation of these communities and the organisational structure needed to perform the different roles at local and global levels.

6.8.1 Organisation and Roles

The organisational structure of the license holder encompasses three areas: governance structure, essential areas and supporting areas. The governance structure ensures the participation of the operating communities in the decisions made by the license holder. The essential areas undertake functions related to the objective or mission of the license holder, which means they are directly related to the operation and the development of the service. Lastly, the supporting areas ensure the continuity of the essential areas.

6.8.1.1 Governance Structure

The governance structure includes a decision-making body and an executive body. In the case study upon which this chapter is based, the decision-making body is an assembly of members in which all operating and technical partners participate.[203] These partners were described in the legal context section. On the other hand, the executive body consists of two representatives of the operating partners and two representatives of the technical partners appointed by the assembly. The role of the executive body is to ensure that the operation of the network is done according to the guidelines proposed by the assembly.

6.8.1.2 Essential Areas

In order to operate effectively, the CN should be based on three key areas: operation, building relationships among communities, and innovation.

203 The operating partners are the communities that manage the network and the technical partners are the individuals, organisations or collectives who are experts on technology or regulation and who contribute to the technological development of the project.

a **Operation:**

This area encompasses the tasks related to network deployment and technical support. This area requires personnel to perform the installation, ensuring the system is operational, and providing technical support for the communities as they deal with any network problem. Since the CN is based on software defined radio, most technical issues or errors can be resolved by improving and developing software.

b **Relationship building amongst the communities:**

Since the organisational architecture of the license-holder is a conjunction of private networks, it is necessary to implement mechanisms catering the specific needs of each local network, as well as improving their interaction. The purpose of the relationship building activities are to bring together local networks and ensure the interaction amongst people and communities. This area aims to allow the organisation to become *a network of networks*.

The relationship building area is aimed at generating actions on behalf of the license holder to improve the capacity of each network and the interaction among them and with the license holder. The tasks performed in his area include: visiting communities to understand the state of the network and the necessities and aspirations of each user; preparing informational materials on the social license holder and the community telecommunications network; and designing training manuals concerning the operation and technical support of the telecommunication equipment used in the communication network.

c **Innovation**

As with any other organisation concerned with technology, the possibility of continued existence is related to its capacity to innovate, increase efficiency and attend to the demands of its beneficiaries. It is important to emphasise that because this technology is relatively new in the context of telecommunications, the equipment and its applications are still under development, hence research and innovation are crucially important.

Given the limited resources available, the Innovation area of a social license holder must be constituted in coordination with universities, hackers, developers, researchers and technology enthusiasts that are able to carry out – mostly as voluntary work – the collective realisation of technical projects and development.

6.8.1.3 Supporting Areas

The main supporting areas are the ones related to administration and finances. One of the most relevant regulatory areas is known as the Institutional Relationships area. Since the administration and finance areas deal with very ordinary and procedural activities, they will not be dealt with in this chapter. In contrast, the Institutional Relationships area deals with regulation that is indispensable for the CNs, though the area does not necessarily comprise the management of the organisation's personnel, since this latter activity can be dealt with by an external organisation.

The relevance of the Institutional Relations area resides in the fact that the model analysed in this paper is a novel one, for which there is no definitive regulation. Therefore, a constant dialogue with the authorities becomes necessary to mitigate risks. Among the essential functions of this area, it is important to note: the coordination the development of regulatory prospective in the context of telecommunications; the approval of political advocacy strategies relating to the regulation of telecommunications; the implementation of the regulatory incidence strategy, building and developing relationships with national government and international institutions and non-governmental organisations; the supervision n of reporting and the follow-up of incidents registered in the CNs and in the communities operating them; and the suggestion of innovations for products, services and processes.

6.9 Conclusions and Challenges

The main value of this project is the establishment of a network that belongs to the users, and fosters self-determination and development. The model described in this chapter aims to provide a mechanism for rural, marginalised and indigenous communities to manage and operate their own mobile telecommunications network in order to encourage local development and to contribute to the construction of local/regional autonomy.

Furthermore, this model increases cellular penetration and reduces costs of connectivity up to 97%, which ensures that part of the income accrues to remain as part of an association to which the community belongs. This is then invested in innovation and training. It also presents possibilities for improvement and development of telecommunication applications suitable for addressing the needs of each community as well as contributing positively to the reduction of the digital divide with corresponding beneficial impact.

After being operational for four years, the Community Mobile Telephony model has proven to be a valid option for communication in isolated areas where no conventional operator has reached. This has encouraged further investment in developing equipment to improve the performance of the one currently used in this model. Furthermore, the Community Mobile Telephony has also helped develop recommendations in terms of regulation for other countries willing to consider this type of approach in their spectrum planning and management mechanisms.

However, an ecosystem that supports the development and expansion of these kinds of models, designed to provide sustainability above profitability, is still needed. Indeed, until now, most of the public policies and regulation concerning telecommunications have concentrated on profitability rather than sustainability.

To truly address the needs of unconnected populations, it is necessary to change perspectives and create the technical, economic and regulatory bases of sustainability, in terms of public policy. In order to do that, it is important that the resources currently being used for universal service funds, which are available in many countries, be used not only to subsidise companies whose business model does not work in rural and remote areas, but also to create the necessary conditions that favour the approaches that work in these areas, such as CNs. Concretely, this means:

- Dedicate funding to support these kinds of social enterprises, from their initial stages to launch;
- Allow access to essential infrastructure such as frequencies and backbone networks from a perspective that considers CNs'

contribution to the fulfilment of a social need in the public interest and the fact that CNs are generally not-for-profit.

- Assign funding for research and development of software and equipment specially designed for these areas and types of entities;
- Create a legal and public policy framework that allows the operation and development of small community operators in rural zones.

This will undoubtedly allow us to achieve the objectives concerning social coverage with a substantial reduction in terms of resources that could be utilised for other areas or to support more projects in these regions.

6.10 References

Benkler, Y. (2005). La riqueza de las redes: Cómo la producción social transforma los mercados y la libertad. Barcelona: Icaria.

Bloom, P. (2015). Comunicaciones en México: Un estudio de caso de las nuevas iniciativas de la Sierra Juárez de Oaxaca. Master's Thesis for the Postgraduate in Rural Development. Mexico City: UAM.

Braudel, F. (1980). On History. Chicago: University of Chicago.

Burket, I. (2010). Using the Busines Model Canvas for Social Entrepreneur Design Knode. Consulted in https://mbs.edu/getmedia/91cc0d01-3641-4844-b34c-7aee15c8edaf/Business-Model-for-SE-Design-Burkett.pdf

Cárdenas, F. (1994). Proporcionalidad y Equidad de los Impuestos en Diccionario Jurídico Mexicano, México: Porrúa-UNAM.

Deleuze, G. & Guattari, F. (2009). Rizoma. Mexico City: Fontamara.

Himanem, P. (2001). La Ética del Hacker y el Espíritu de la Era de la Información 2001. Consulted in http://eprints.rclis.org/12851/1/pekka.pdf

Huerta, E. (2013). Recomendaciones de política pública para el desarrollo de las TIC en comunidades indígenas, International Telecommunications Union: País. http://connectaschool.org/es/itu-module/14/330/es/ind%C3%ADgenas/educaci%C3%B3n/sociales/econ%C3%B3mica/desarrollo/introducci%C3%B3n/

Huerta, E. (2016). Manual de Telefonía Celular Comunitaria: Conectando al siguiente Millón, Redes por la Diversidad, Equidad y Sustentabilidad A.C. Mexico City. Consulted in https://docs.wixstatic.com/ugd/68af39_c12ad319bb404b63bd9ab471824231b8.pdf

Laval, C. & Dardot, P. (2015). Común: Ensayo sobre la revolución en el siglo XXI. Barcelona: Gedisa.

Lessig, L. (2001). The Future of Ideas: The Fate of the Commons in a Connected World. Nueva York: Random House.

Instituto Federal de Telecomunicaciones (2015). PROGRAMA ANUAL DE USO Y APROVECHAMIENTO DE BANDAS DE FRECUENCIAS 2015 http://www.dof.gob.mx/nota_detalle.php?codigo=5387867&fecha=06/04/2015

Instituto Federal de Telecomunicaciones (2016). PROGRAMA ANUAL DE USO Y APROVECHAMIENTO DE BANDAS DE FRECUENCIAS 2016 http://www.ift.org.mx/sites/default/files/conocenos/pleno/sesiones/acuerdoliga/dofpift230915406.pdf

Organisación de los Estados Americanos. (2010). Una agenda hemisférica para la defensa de la libertad de expresión.

Özveren E. (2005). Landscape of a Political Convergence, en Finch & Orillard Complexity and the Economy Implications for Economic Policy. UK: Edward Elgar Publishing.

Peralta, J. (14 de noviembre de 2011). Mitos y cuentos del espectro. Revista Etcétera. Consulted in http://www.etcetera.com.mx/articulo/Mitos+y+cuentos+del+espectro/10100

Rendón, J. (2003). La comunalidad. Modo de vida de los pueblos indios. Tomo I. Cultura Indígena. México: Conaculta.

Umemoto (2006). https://es.slideshare.net/asaito/knowledge-economy-and-society

PART II

Case Studies: Building Connectivity in a Bottom-up Fashion

7 Policy Gaps and Regulatory Issues in the Indian Experience on Community Networks

Ritu Srivastava

This paper is based on content previously published in Srivastava. (2017). Community Networks: Regulatory issues and gaps – Experiences from India. Internet Society.

Abstract

The emergence of a global "information society" is driven by the continuing development of converging telecommunications, multimedia broadcasting, and information technologies. The Internet has become one of the most dynamic communications tools the world has ever seen. The flow of information that it facilitates strengthens democratic processes, stimulates economic growth, and allows for cross-fertilizing exchanges of knowledge and creativity in a way never seen before.

This document takes the Delhi, India-based Digital Empowerment Foundation's (DEF) Wireless for Communities (W4C) model as a case study to understand the legal and regulatory challenges of spectrum allocation and management, licensing regulation, and bandwidth issues in developing countries. The first section of this document maps out the common elements of these challenges among community network providers, while the next section addresses the policy, legal, licensing, and bandwidth problems in India. This document investigates the efficacy of creating wireless community networks (WCNs), Rural Internet service providers (RISPs), or Community-based Internet Service Providers (C-ISPs), and explores the possibility of policies, which could help in creating widespread information infrastructure for the country to better connect the subcontinent.

The closing section includes several recommendations for policy-makers, regulatory bodies, legislators, and related stakeholders that are divided into national recommendations and regional and international recommendations. The national recommendations include suggestions for how to alleviate unnecessary regulatory and fiscal hurdles on small and rural ISPs and community networks in India. The regional and international recommendations focus on creating a more enabling policy and regulatory environment for community networks in general and is applicable to any national context.

7.1 Introduction

Connectivity plays a fundamental role to remove the socio-economic barriers. According to the 2016 International Telecommunications Union's (ITU) State of Broadband report, there are about 3.5 billion people out of 7 billion people who are currently connected to the Internet.[204] This means that it took around 25 years to connect half of the world, but will it take another 25 years to get the remaining online? More than two decades ago, the Internet started a revolution and then Internet-connected mobile phones further expanded this revolution. Current trends suggest that something else could become a telecommunications revolution in the years to come.

Over the past 15 years, the Delhi, India-based Digital Empowerment Foundation (DEF)[205] has established one of the largest community wireless networks in India. It has provided digital literacy skills and enabled connectivity in regions where traditional and mainstream Internet service providers (ISPs) either do not wish to expand or simply do not deem as relevant markets. They have also pioneered the process of training local community members, many of which have not completed a formal education, to maintain community infrastructure.[206] Barriers to connectivity exist around the world, but many of these barriers can be eliminated through community-driven solutions and partnerships. As the director of DEF, Osama Manzar, stressed: "Half the population is still not connected. And most of those 3.5 billion people are socially underserved and economically impoverished. Last mile connectivity with innovative ideas as the means of basic infrastructure would make the work better and [more] equal."

It is believed that the global information highway is a two-way communication process through which information flows, without information barriers,[207] thus empowering individuals regardless

---

204 Broadband Commission for Sustainable Development (2016).

205 For more information, see: https://defindia.org. Additional information is also available at https://www.internetsociety.org/sites/default/files/pub-IEEEIC-201205-en%20Wireless%20for%20Communities%20%281%29.pdf.

206 For more information, see https://www.internetsociety.org/blog/development-asia-pacific-bureau/2016/12/build-internet-training-barefoot-network-engineers.

207 The expression "information barrier" or "digital information barrier" refers to the asymmetric distribution of information and the effective use of information and communications resources.

of the fact that they live in remote areas. Such empowerment is only possible if Internet connectivity is not only available but also affordable for rural and remote individuals to access and share the wide range of information available on the Internet, spanning from market prices, weather information, new opportunities, and new skill sets, to discovering traditions, food recipes or how-to videos. Internet content covering the various economic, social, educational, and cultural aspects of human life is growing every day. Yet, many communities are being denied from the current opportunities that the Internet provides due to non-availability of the Internet or limited access. Gaining access to the rich opportunities the Internet promises is increasingly possible when communities build their own sustainable networks using existing resources, while also having the skills and capacity to manage the network on their own.

Wireless community networks (WCNs) or Community-based Internet service providers (C-ISPs)[208] are networks whose infrastructure is developed and built by a community-driven organisation or by a community itself by pooling their existing resources. These networks are also being managed, operated, and administered by the communities tehmsleves. These networks provide affordable access to the Internet, while also strengthening the local economy.[209] There are hundreds of Community Networks (CNs) around the world.[210] Among them, more than 100 CN models have adopted a bottom-up approach and work as an alternative model instead of adopting the classic, telecom operator-driven, top-down approach. Some of these networks are located in Latin American countries such as Argentina, Brazil or Mexico; in Sub-Saharan African countries, such

208 "Community networks, which can be broadly defined as telecommunications infrastructure deployed and operated by citizens to meet their own communication needs, have been part of the foundations of Internet infrastructure since [its] early days. In recent years, the community networks movement has grown consistently, leading more and more voices to point to them as a solution for connecting the next billion, due to [the] increasing evidence of the role they do, and can, play." Quoted on page 6 of the May 2017 Internet Society report, "Supporting the creation and scalability of affordable access solutions: Understanding community networks in Africa," available at https://www.internetsociety.org/sites/default/files/CommunityNetworkingAfrica_report_May2017_1.pdf.

209 Center for Neighborhood Technology (2006).

210 For extensive catalogues and lists of community networks, see https://goo.gl/oahE3H and Baig *et al*. (2015).

as South Africa, Kenya, Ghana, Congo; in Asia-Pacific (India, Nepal, Pakistan, Indonesia, Australia, Afghanistan), in the United States, Canada, and Europe (Germany, Austria, Hungary, Spain, Greece, Sweden, Croatia). Each CN uses different technology, different tools, and works under different regulatory models with different socio-economic and cultural conditions. Thus, even though many share common characteristics, each CN is ultimately unique and different from the others.

For example, DEF's Wireless for Communities (W4C) program[211] is one such wireless community network that is trying to provide affordable, ubiquitous, and democratically controlled Internet access in rural regions of the country. W4C is a flagship initiative of DEF and the Internet Society (ISOC) that aims to provide connectivity to rural and remote locations around India. The network enables community economic development that can reduce poverty and encourage civic participation. At the same time, the CN has faced – in some cases, still faces – regulatory, policy, licensing, and legal challenges while building and establishing the infrastructure. Some of these policies are not encouraging CN providers but instead hamper the process of establishing wireless networks in rural parts of the country.

This document explores community wireless models like DEF's W4C program to understand the regulatory, policy, spectrum, and legal challenges in India. Subsequently, the document identifies the common elements of policy, legal, and regulation challenges among other CNs operating in other countries around the world. The document presents recommendations that aim to inform national, regional, or international policy and regulatory frameworks. This document is also part of a series of policy briefing papers that will address technological, content, sustainability, and organisational challenges, among others, which require further discussion in both their relevant national venues as well as at regional and global policy fora.

211 For more information, see http://wforc.in/

7.1.1 Research Objective

The prime objective of this document is to understand the legal issues surrounding spectrum allocation and management, licensing regulation, and bandwidth issues in India and to draw conclusions that can be applied to a wide range o developing countries. The document also outlines the technological and infrastructural challenges from a policy perspective in India. The document aims to identity the common elements of policy, legal, licensing, regulation, and bandwidth issues that have been faced by various CN providers across the world, as well as provide a set of recommendations coupled with qualitative analysis and evidence to determine what measurements need to be considered from the legal, regulatory, and policy perspectives to leverage CNs and other aspects of sustainability.

7.1.2 Methodology

This policy document largely draws from secondary research, including academic literature as well as government and regulatory documents, to analyse existing policies and programs. For this paper, we adopted two mapping methodologies, examining, on the one hand, existing policies and, on the other hand, relevant stakeholders. This included mapping CN providers based on their location and model; organisations that are working nationally and internationally to assist CNs; and academic institutions that are working with and/or helping to assist CNs. For the purposes of this research, CNs have been mapped geographically by region, and we identified four large-scale CNs that are operating in their respective country. We covered at least two CNs per region.

The community networking professionals we interviewed included:

Name	Community network affiliation	Country
Mahabir Pun	Nepal Wireless Networking Project	Nepal
Josephine Miliza	TunapandaNet	Kenya
Carlos Rey-Moreno	Zenzeleni Networks	South Africa
Anya Orlova	Amazon Digital Radio Network using High Frequency	Brazil
Leandro Navarro	Gulfi.net	Spain

7.2 Definition of Community Network

CNs, also known as bottom-up community networking, are networks built by communities and organisations, pooling their resources for building network infrastructure. These common pooling of resources is known as common pool resources (CPR).

Various definitions of community networking exist, ranging from academic and technical definitions to government and regulatory definitions. For instance, Saldana *et al.* (2016) outlines community networking as the following: "Any participant in the system may add link segments to the network in such a way that the new segments can support multiple nodes and adopt the same overall characteristics as those of the joined network, including the capacity to further extend the network."[212] Similarly, Baig *et al.* (2015) defined community networks as "crowdsourced networks," ones that are structured to be free, open, and neutral. These crowdsourced networks are built by community members and are managed as a common resource. Elkin-Koren (2006) defined CNs as distributed architectures in which users implement a physically decentralised network through the decentralisation of the hardware. The architecture of CNs is normally used for users' interactions, including messaging or sharing data. The main use of CNs is to bring Internet-related services in such locations where ISPs do not offer Internet-related services. It depends whether these networks are profitable or not, but these models operate as an alternative approach to provide Internet connectivity in remote regions. Conversely, the European Commission (EC) defines the community broadband model as "a private initiative by the local residents of the community using a so-called bottom-up approach."[213]

The IGF Dynamic Coalition on Community Connectivity has facilitated convergence around a shared definition of CNs as "a subset of crowdsourced networks that are structured to be open,

212 Saldana *et al*. (Eds.) (2016). For further readings, see Belli (2016).

213 The idea of a decentralized network was key in creating the Internet: a network of networks without any central node would have been more resilient to possible attacks. Yet, the Internet then evolved in a different way, as today it is infamously clear that it mainly relies on a few operators and on large nodes. For more information, see: pp. 20-21 of Elkin-Koren (2006).

free, and neutral. These networks rely on the active participation of local communities in the design, development, deployment, and management of the shared infrastructure as a common resource, and is owned by the community and operated in a democratic fashion. Community networks can be operationalized wholly or partly through local stakeholders, local organizations, nongovernmental organizations (NGOs), private sector entities, and/or public administrative or governmental bodies."[214]

Regardless of the definition, wireless CNs represent an emerging model able to shape the future of the Internet so that communities are able to deploy, manage, maintain, and operate their own networks. These networks are part of the Internet but present various "exceptional" features, including: low cost and effective public documentation on every technical and non-technical aspect; they operate and own open Internet Protocol (IP)-based networks; they are built by communities of individuals; and are based on collective digital participation.

Most often, these networks rely on Wireless Mesh Networking Technology (WMNT).[215] Wireless CNs comprise nodes that not only generate data but also route other nodes' traffic. The structures of these mesh networks are often made of stand-alone devices, permitting the connection of numerous nodes depending on the expansion of the network. Since the nodes, known as "connected nodes," interlink, members who are connected to a particular node can then access the Internet. This occurs since data travels from one connected node to another in order to reach the primary node that is connected to the Internet, which is also known a the "gateway node." This way, one CN connects to another community and enables them to access the Internet for their specific purposes relevant to their local interests and needs.[216]

In India, community networks are not specifically defined. "The Consultation Paper on the Proliferation of Broadband through Public Wi-Fi Networks" by the Telecom Regulatory Authority of

214 See Declaration on Community Connectivity, at p. 237 of this book. The Declaration is also available at https://comconnectivity.org/article/dc3-working-definitions-and-principles/

215 For an overview of wired and wireless networking technologies, see Settles (2017).

216 For more extensive information, see Butler (2013).

India (TRAI)[217] identifies them as "public Wi-Fi' networks." The TRAI document has given a broader meaning and not limited to the Wi-Fi hotspot created and/or licensed by telecommunications service providers (TSPs)/ISPs in public places. The document also identifies that small entrepreneurs and even a very small private entity would like to participate in common and shared Wi-Fi networks for larger public use.

Considering the elements put forward by the TRAI document and the importance of CNs in India and around the world, we have striven to highlight challenges DEF's projects have faced in this context. By doing this, we have identified recommendations to remove barriers for CNs in India to benefit communities and empower people throughout the subcontinent. We also expect that our recommendations will be of use to global stakeholders interested in developing and deploying their own networks and connect the unconnected around the world.[218]

7.3 Community Network Models in India

In India, there are few social enterprises or community-based models working to design or deploy wireless network models that can cater connectivity to communities. DEF,[219] AirJaldi[220] and Gram Marg[221] are some of the only CN models operating in India, which are providing basic Internet connectivity and enabling access to information for people who are living in the most rural and remote regions of the country and/or those unable to afford traditional Internet services provided by the established telecom providers.

AirJaldi started as a social non-profit enterprise in Dharamshala, in the state of Himachal Pradesh, providing affordable wireless broadband connectivity in the most remote rural areas at a

217 TRAI (2016).

218 For an extensive list of policy recommendations for connecting and enabling the next billion(s), see IGF (2016).

219 DEF is also involved in an initiative called Barefoot College, which trains middle-aged women from rural villages worldwide to become solar engineers. In partnership with local and national organisations, the Barefoot College team establishes relationships with village elders, who help identify trainees and implement community support. For more information, see https://www.barefootcollege.org/

220 See https://airjaldi.com

221 See http://grammarg.in

reasonable cost. Two Israeli engineers, Yahel Ben-David and Michael Ginguld, frequently visited Dharamshala and wanted to do something for the development of Tibetan refugees. Hence, they founded AirJaldi to provide Internet connectivity to them. The idea behind initiating AirJaldi was to connect local institutions and the Tibetan refugee community to and through the Internet. However, there was no infrastructure available to them at the time. AirJaldi provides a community-based wireless mesh network in cooperation with the Tibetan Technology Centre (TTC) in Dharamshala. The mesh backbone includes more than 30 nodes, all sharing a single radio channel, and broadband Internet services are provided to all mesh members. The total upstream Internet bandwidth available is 6 megabits per second (Mbps). There are more than 2,000 computers connected to the mesh, and about 500 have Internet access – the rest are connected locally and utilise an intranet.

Mumbai-based Gram Marg is an incubation of the Rural Broadband Project in the Department of Electrical Engineering at the Indian Institute of Technology (IIT) Bombay that is providing rural connectivity using TV white space (TVWS).[222] In India, however, there is no framework regulating the use of TWVS for community connectivity. In 2015, the Department of Telecommunications (DoT) of the Government of India granted an experimental license to IIT Bombay to conduct tests using the TV ultra-high frequency (UHF) bands. This was the first time that such experiments were conducted in India on this scale.

DEF and the abovementioned social enterprises are using alternative technology instead of fibre broadband or traditional ISP provision, whether it is wireless mesh networking or TVWS, to provide connectivity in the most remote locations of the country. However, these alternative models also face various levels of policy and regulatory challenges, ranging from spectrum management and regulation to spectrum availability, licensing processes, regulation of ISPs, and compliance issues that hamper the growth of Wi-Fi services and CNs in India. Based on the DEF example, the next sections of this chapter will elaborate on unlicensed spectrum

222 Gram Marg uses underutilized TV band spectrum (called white space) for rural broadband access. For more information on TV white space, see http://wireless.ictp.it/tvws/book/

policy and related regulatory frameworks, spectrum management, bandwidth, and technical and regulatory challenges. They will also investigate the efficacy of creating WCNs, RISPs, or C-ISPs, and explore the possibility of policies that could help create widespread information infrastructure for the unconnected communities and individuals in developing countries.

7.4 Wireless for Communities (W4C)

W4C is an initiative of DEF and ISOC that has been supported by various partners over the years. Launched in 2010, W4C aims to connect rural and remote locations of India, where mainstream ISPs are unwilling to provide Internet connectivity as they feel their operations would not be commercially viable. W4C employs line-of-sight and low-cost Wi-Fi equipment using the 2.4 gigahertz (GHz) and 5.8 GHz unlicensed spectrum bands to create community-owned and community-operated wireless networks in rural and remote locations of India to democratise access and make it available to all.

The networks established by W4C strives to provide affordable, robust, ubiquitous, and democratically controlled Internet access in rural regions of the country. The networks enable community economic development that can reduce poverty and encourage civic participation. The impetus behind the project was twofold. First, democratise the availability of connectivity, and provide Internet access to information in rural and remote parts of the country. Second, address the lack of content, products, and services originating from rural areas, which inhibits the economy from filtering down. The program has four main components:

1. Training the trainers in technological know-how of wireless networking, and transform them into barefoot wireless engineers to link rural populations to the Internet;
2. Deploying wireless across rural communities, especially in clusters;
3. Creating an open forum to discuss best practices and lessons learned, and to educate on issues from both a technical and policy perspective; and

4 Advocate for social enterprises and NGOs to become rural ISPs, especially by opening new channels to decision-makers, regulators, government officials, the private sector, civil society, and the technical community.

Even in areas with infrastructure, people often lack the skills to use the Internet to its full potential. The lack of content in local languages as well as inadequate information and communications technology (ICT) training are reasons for less adoption in rural areas as compared to urban areas. Thus, in the last six years, W4C has connected rural and remote locations in as many as 38 districts across 18 states of India with more than 200 access points while connecting more than 4,000 people — and the numbers only continue to grow. Over the years, several of DEF's projects have been inspired by W4C's wireless ecosystems and several other initiatives have emerged out of the W4C umbrella project. One such initiative has been the Wireless Women for Entrepreneurship & Empowerment (W2E2).[223]

Most of these networks are in tribal and underserved areas where people have never used a computer and are unaware about how the Internet can be a part of their lives and help fulfilling their needs. The Baran W4C network is one of the widest coverage networks under the project. The network is spread across 200 kilometres and about 10 community information resource centres (CIRCs), which facilitates health and educational services among others. The Baran network serves Rajasthan's two tribal communities, Bheel and Sahariya. Even if there is a disruption to the Internet backhaul[224] providing connectivity, communities living in two different villages can still communicate using intranet infrastructure that exists in the network. This way, they are always connected by either its connection to the Internet or intranet infrastructure.

Another network is in the tribal-dominated district of Shivpuri, in the state of Madhya Pradesh. The region is also classified as one of

223 For more information, see http://defindia.org/w2e2/.

224 Backhaul comprises the intermediate links between the core network or backbone network and the small sub-networks on the "edge" of the hierarchical network. For more information, see: https://www.youtube.com/watch?v=v-Jog34Ovco.

the most backward districts of India,[225] and is also a pivotal centre for the W2E2 project, as 10 female entrepreneurs are leading the W4C network in Shivpuri.

The Guna district is another underdeveloped and tribal dominated region in Madhya Pradesh. However, the Guna network is the hub that provides Internet connectivity to three other tribal blocks, and it features the biggest wireless training centre for barefoot engineers. It has created more than 25 barefoot wireless engineers so far.

Zero connect is another W4C project that reaches out to the Agariyas (salt farmers) community living in Little Rann of Kutch (LRK), a salt marsh located Kutch district, in the Gujarat state. For eight months a year, 3,500 Agariya families inhabit LRK as their home.[226] During this period, they live secluded lives as their farms are scattered far apart, yet communication has never been a problem for them as they have developed a language of signals. The Zero Connect project, also known as India's Survey Number Zero, is helping to give the Agariyas a digital voice through which they can communicate within and outside their community. The project has been designed innovatively using a variety of wireless technology and devices, which are built into a mobile van. The vehicle has rooftop solar panels, backup batteries, and an expandable and flexible 5-meter, tripod-based antenna tower with a dish antenna. The dish antenna can rotate a full 360 degrees, and depending upon where the vehicle is parked, it aligns with the broadband Internet tower on the periphery of the LRK. The Zero Connect vehicle reaches out to 17 schools and a number of settlements that invariably lie at a distance of 20 kilometres to 50 kilometres from a backhaul-provided Internet tower. The antenna on the vehicle catches Internet from the tower using unlicensed spectrum with complete security, and further allows Wi-Fi access to local identified users in a radius of 100 meters.

---

225 "Backwards" is a collective term used by the Government of India to classify areas and individuals that are socially and educationally disadvantaged, usually in reference to those of particular castes. For more information, see: http://www.ncbc.nic.in/Home.aspx?ReturnUrl=%2f.

226 For more information, see: http://vimages.net/2017/03/28/zero-connect/the-little-rann-of-kutch-is-known-as-indias-survey-number-zero/.

In the last six years, DEF has providing training to local community members to operate wireless technology and deploy them to link rural populations to the vast information available on the Internet. To reinforce the local dimension of the initiative, the project strengthens grassroots expertise by training community members in basic wireless technology, enabling these "barefoot engineers" to not only run and manage these networks, but also pass on their skills to others. The program also provides local content development and technology support to barefoot engineers.

Box: the case of Baran

Baran is a unique district in Rajasthan where time stands still. Spread across a 7,000 square kilometer (km^2) area, Baran has just 82 km^2 that is designated as urban. Out of the population of 1 million, more than 40% are scheduled castes and scheduled tribes.[227] About 60% of women are illiterate, while 85% of the residents live in rural areas. The Sahariyas and Bheels are the majority among the tribes of Baran, who are mostly nomadic, homeless, and bonded laborers. They make a living on a day-to-day basis. Most people outside the area are not even aware of the Sahariyas' existence, as they live in a media-dark location.

While traveling within the interior of Baran, there are few Wireless in Local Loop (WLL) towers erected by the state-owned telecommunications company Bharat Sanchar Nigam Limited (BSNL), and some of those towers are not operational. DEF started its Baran network with the help of Sankalp, a community-based, non-profit organisation that has been working in Baran, in the areas of Bhanwargarh and Mamoni. The only connectivity that was available at the time was only available if you have mobile phone and were close to the signal tower. DEF had given 10 computers and began establishing the network, but there was no nearby tower in Bhawargarh.

227 See http://in.one.un.org/task-teams/scheduled-castes-and-scheduled-tribes/

They created five centres in various locations with just two computers each, and showed tremendous results, but, unfortunately, there was no connectivity to connect these five centres.

Ironically, none of the ISPs or telecoms are interested in providing connectivity, perhaps because of low volumes of traffic and the relatively high cost of deploying infrastructure in the area. So, to cope with this unfortunate situation, community members living in Bhawargarh started using scrap material to build a 40-feet-high (12.2 meter) tower. Currently, the tower is built and operational and it is providing connectivity in seven centres. In most of such cases, however, community members are not aware of the regulatory challenges that exist. For instance, they were not aware of the legal and regulatory conditions that govern telecommunications towers. As a result, they did not realise that the construction of the tower could be categorised as illegal activity.

Besides the deployment of wireless community networks in the most remote regions of the country, DEF has been continuously advocating for RISPs to democratise Internet access uniformly. In the last six years, through its W4C program, DEF has proven that the use of unlicensed spectrum is an effective method of creating CNs and providing last mile connectivity. At the same time, however, DEF is making an effort to address the restrictions related to policy and regulatory challenges, which are hampering the development of wireless CNs.

The next section of the paper identifies the broadband regulatory framework regarding spectrum, spectrum management issues, bandwidth, and technical regulatory challenges in India, and compares these elements with other countries where CNs are operating.

Connected people:	4,000
Access points:	200
Districts covered:	38
States:	22

2010	Inception of the project by DEF and ISOC.
2011	Expanded to three more locations: one in Meghalaya (Tura), and two in Rajasthan (Baran and Tilonia).
2012	Expanded to eight locations; built a unique 200-kilometer wireless network for the Sahariya tribe in the Baran district of Rajasthan. Connected 10 centers located within a range of 40 kilometers.
2013	The first wireless training center established in Guna connected more than 100 users.
2014	Wireless network becomes a strategic tool across 150 locations in 22 states.
2015 e 2016	Building expertise in wireless technology; promoting the idea of rural ISPs or community ISPs; establishing a new social enterprise called Villages of India Network (VOIN).
2016 e 2017	Started providing connectivity to the Agariyas community who are not counted as part of the Indian constitution.

7.5 Public Policy AND Regulatory Environment

Public policies and regulations may facilitate or hinder the development of CNs. In a country like India, it is important to understand that the possibility of establishing and operating CNs may be directly or indirectly affected by policies and regulations, which are being implemented at the local, national, and/or international levels.

As emphasised by Belli, Echániz & Iribarren (2016:17), the success of any CN depends upon a variety of factors such as organisational features and the participation of community members, but also the need for a favourable policy environment. For instance, legislation required for establishing data retention obligations for network operators or imposing the responsibility to secure one's connection to network users may jeopardize the development of CNs since the CN operator can be an undefined community and its users may be identifiable.[228]

Spectrum policies may be particularly challenging because they usually do not consider the necessities of CNs and they may be defined at several administrative levels. In Spain, for instance, spectrum allocation is not defined via domestic policy, because the issue is regulated by the European Union (EU).[229] In the EU, the member states coordinate their spectrum management approaches in a common regulatory framework to support the internal market for wireless services. The European Commission works together with member states to modernise spectrum management and to facilitate spectrum access through more flexibility in usage conditions. The EU also establishes the policy priorities in cases where there is conflict between requests for spectrum use. The EU Spectrum Policy Framework[230] also establishes the regulatory environment for access to radio spectrum with the aim of easier and more flexible access by public and private users. At the same time, however, in terms of sharing infrastructure in Spain, municipalities inter-regulate the public space and public infrastructure, including towers, network pipes, *etc.*, but they cannot regulate spectrum frequency, since it can only be regulated by the individual member states.[231]

In South Africa, the national ICT and broadband plan[232] recognises CNs but CN operators are not regulated. If they need to provide universal access in areas with unmarketable services, they need to comply with the appropriate regulations and identify what is applicable for them or what is needed. Also, CNs in South Africa need three different types of licenses: one for setting up infrastructure, one for spectrum use, and one for conducting electronic services.[233]

228 See Belli, Echániz & Iribarren (2016).

229 Interview with Leandro Navarro, Guifi.net (Spain).

230 Available at: https://ec.europa.eu/digital-single-market/en/content/eus-spectrum-policy-framework.

231 Interview with Leandro Navarro, Guifi.net (Spain).

232 See National e-strategy (2017).

233 Interview with Carlos Rey-Moreno, Zenzeleni Networks (South Africa).

In Kenya, there is no specific policy to support the establishment of CNs.[234] The Communications Authority of Kenya[235] is responsible for facilitating the development of the information and communications sectors, including broadcasting, multimedia, telecommunications, electronic commerce (e-commerce), postal services, and courier services. Yet, there is a lack of awareness about what the authority mandate covers, especially *vis-à-vis* spectrum regulation, regarding entities that fall outside of the usual telecom parameters, such as CNs. Furthermore, of the little information that is available for public access, it is not easily accessible and/or uses language that is difficult to understand.[236]

In many African countries, licensing processes are expensive as well as require extensive documentation.[237] Similarly, there is no specific policy that supports CNs in Brazil. Although there are some talks currently happening at the National Telecommunications Agency of Brazil (ANATEL) that seek to address CNs and CN-related policy, nothing concrete has materialised yet. Moreover, most of the existing laws and regulations are made for the large, established telecommunications networks/companies and related stakeholders.[238]

According to the CN professionals we interviewed, many countries from various regions around the world lack clear policies and regulation for community networks, which often creates additional challenges. Furthermore, there is often no specific policy or regulation defined for CNs by the relevant government bodies. It was also noted that much of the information related to policy and regulation affecting CNs is not easily accessible or the awareness of such policies is limited within regulatory bodies or the appropriate authorities. On a positive note, many countries have allocated some spectrum for unlicensed use, and unlicensed spectrum bands can be either utilised for general purpose or application specific.[239] Most of these networks, however, are

234 Interview with Josephine Miliza, TunapandaNet (Kenya).

235 For more information, see: http://ca.go.ke.

236 Interview with Josephine Miliza, TunapandaNet (Kenya).

237 Internet Society. (2017).

238 Interview with Anya Orlova, Amazon Digital Radio Network using High Frequency (São Paulo State University) (Brazil).

239 For more information, see Butler (2013).

operating without following any specific regulation or operational guidelines set by the government and/or related authorities. The table below summarises the answers given by six community networking professionals we interviewed, and defines how the CN providers see the regulatory challenges as it relates to spectrum:

Interview question	Country					
	Brazil	Kenya	South Africa	Spain	Nepal	India
Does the spectrum management exist in the country?	✔	Partially	✔	✔	✔	✔
Is their legal and business challenges related to spectrum allocation?	✔	✔	✔	✔	✔	✔
Does the country allow unlicensed use of spectrum or spectrum sharing or secondary use of spectrum?	✔	✔	✔	✔	✔	✔
Does the country have specific policies that support CNs?	✘	✘	✔	✘	✔	✘
Does the country allocate specific spectrum for CNs?	✘	✘	✘	✘	✘	✘
Is there a spectrum-licensing process in the country?	✔	✔	✔	✔	✔	✔
Are community networks allowed to set-up/operate a network in your country?	✔ License required	Neither legal nor illegal	✔ License required	✔	✔ License required	✔

The table above shows that, most of the CN providers are using unlicensed spectrum to provide connectivity in rural and remote regions. Moreover, the table highlights that most of the governments relevant for the CNs have some type of management authority in place to manage spectrum allocation, but there is no specific policy to allocate spectrum for community networking purposes.

7.5.1 Examples of Unlicensed (License-exempt) Spectrum Policies

The continuously evolving nature of spectrum applications and radio devices has greatly reduced the risk of interference between signals using the same spectrum bands, and created a need to devise methods in which spectrum can be managed effectively and efficiently. Modern technologies such as Orthogonal Frequency-Division Multiple Access (OFDMA), spread spectrum, frequency hopping, Beam Division Multiple Access (BDMA), fixed-mobile convergence (FMC), Ultra-Wide Band (UWB), and the potential for Software-Defined Radio (SDR)[240] further facilitate spectrum sharing, enabling spectrum signals to coexist with each other without interference. The carrying capacity of spectrum depends entirely on the technology that is used, but it is increasing day-by-day.[241]

The ITU Radiocommunication Sector harmonises the radio frequency (RF) spectrum allocation at the international level. According to the ITU, both vision and commitment are required when implementing policies for spectrum unlicensing, which results in the most efficient and optimum sharing of the resource. Spectrum policies should motivate innovation, be flexible so that communities can also participate or engage, and set out spectrum users' rights. The ITU has advised all countries to adopt the approaches utilised by regulators like the U.S. Federal Communications Commission (FCC) and the U.S. National Telecommunications and Information Administration (NTIA) by establishing a Spectrum Sharing Innovation Test-Bed.[242]

Importantly, during the World Radiocommunication Conference (WRC) held by the ITU in 2003, spectrum in the 5-6 GHz range was allocated for unlicensed use. Countries like the United States, United Kingdom, and Canada have unlicensed these frequencies

240 Unlicensed Spectrum. (2011). *ICT Regulation Toolkit*. Retrieved from: www.ictregulationtoolkit.org/en/Section.2843.

241 For example, see Clarke, R. N. (2014). "Expanding mobile wireless capacity: The challenges presented by technology and economics." *Telecommunications Policy*, 38(8–9), Pp. 693-708. Retrieved from: http://www.sciencedirect.com/science/article/pii/S0308596113001900. Also see: Idachaba, F. E. (2017). "Spectrum bundling architectures for increased traffic capacity in mobile telecommunication networks." *Proceedings of the International Multiconference of Engineers and Computer Scientists*, Vol. II. Retrieved from http://www.iaeng.org/publication/IMECS2017/IMECS2017_pp624-627.pdf.

242 For more information, see https://www.ntia.doc.gov/category/spectrum-sharing & https://www.ntia.doc.gov/files/ntia/publications/fy12_test_bed_progress_report_march2013.pdf.

consistent with the decision made at the WRC.[243] In this sense, the FCC subsequently de-licensed the 5.15-5.35 GHz and 5.725-5.825 GHz frequencies, and also added 5.47-5.725 GHz to the Unlicensed National Information Infrastructure (U-NII) band.

In the EU, the Authorisation Directive lists regulations for the authorisation of ICT services and networks within the Union.[244] According to Article 5.1:

> Member states shall, where possible, in particular where the risk of harmful interference is negligible, not make the use of radio frequencies subject to the grant of individual rights of use but shall include the conditions for usage of such radio frequencies in the general authorisation.

Hence, in the EU, unlicensed and class licensed[245] use of spectrum is implied by general authorisation, whereas the rights of use are referred back to licensing processing.[246] It is important to note that, in March 2003, the European Commission proposed that its member states de-license the 2.4 GHz and 5 GHz bands to administer public communication networks and services and this choice resulted in an increase of Wi-Fi bands in most EU member states. The EU has also de-licensed the 433-434 megahertz (MHz) band, along with Australia, Malaysia, New Zealand, and Singapore.[247]

In Brazil, the Transmit Power Control (TPC) use in the 5.150-5.725 GHz band is optional and Dynamic Frequency Selection (DFS) is only required in the 5.470-5.725 GHz band. In China, the Ministry of Industry and Information Technology (MIIT) has expanded and allowed channels to be de-licensed as of 31 December 2012 to add U-NII-1, 5150 ~ 5250 GHz, U-NII-2, 5250 ~ 5350 GHz (DFS/TPC). India has also followed a similar strategy, although only partially.

---

243 Longford & Wong (2007).

244 The EU Authorisation Framework. (2011). *ICT Regulation Toolkit*. Retrieved from www.ictregulationtoolkit.org/en/Section.539.

245 In a class licensing scheme, users of a band are given non-exclusive licenses that are usually accessible to all. These licenses can be free or come with a nominal fee. Other requirements that may come with light licensing are the registration of locations for transmitters and the coordination of their deployment with other users.

246 ECC (2009).

247 For more information, see Manzar (2014).

The next section will expand on the definition of broadband and unlicensed spectrum, and further elaborate on the 2004 Broadband Policy and the National Telecom Policy that favours unlicensed spectrum in India. The section will also examine how spectrum is being managed and allocated by the Indian government and its related bodies.

7.5.2 Policy and Regulatory Environment in India

In their February 2009 document "Revisions and Additions to the Core List of ICT Indicators,"[248] the United Nations (UN) defined fixed and mobile broadband separately in view of technological advancements in wireless and the increasing number of mobile broadband subscribers worldwide. Fixed and mobile broadband were re-defined as follows:

> Fixed broadband refers to technologies at speeds of at least 256 kilobits per second (kbps), in one or both directions, such as digital subscriber line (DSL), cable modem, high-speed leased lines, fiber-to-the-home, power line, satellite, fixed wireless, wireless local area network (WLAN), and Worldwide Interoperability for Microwave Access (WiMAX).
>
> Mobile broadband refers to technologies at speeds of at least 256 kilobits per second (kbps), in one or both directions, such as Wideband Code Division Multiple Access (W-CDMA), known as Universal Mobile Telecommunications System (UMTS) in Europe; High-speed Downlink Packet Access (HSDPA), complemented by High-speed Uplink Packet Access (HSUPA); and CDMA2000 1xEV-DO and CDMA 2000 1xEVDV. Access can be facilitated via any Internet-connected device (handheld computer, laptop, tablet, mobile phone, etc.).

According to the 2004 Broadband Policy of the Government of India,[249] broadband is defined as:

248 Partnership on Measuring ICT for Development (2009).

249 Government of India (2004).

> An "always-on" data connection that is able to support interactive services, including Internet access, and has the capability of the minimum download speed of 256 kilobits per second (kbps) to an individual subscriber from the point of presence (PoP) of the service provider intending to provide broadband services – where multiple such individual broadband connections are aggregated – and the subscriber is able to access these interactive services, including the Internet, through this PoP. The interactive services will exclude any services for which a separate license is specifically required, for example, real-time voice transmission, except to the extent that it is presently permitted under ISP license with Internet telephony.

The 2012 Indian National Telecom Policy (NTP)[250] aimed to "provide secure, reliable, affordable, and high-quality converged telecommunication services anytime, anywhere for accelerated, inclusive socio-economic development." The vision of the NTP is to transform the country into an empowered and inclusive knowledge-based society, using telecommunications as the catalyst. The NTP dictates the need for robust, reliable, and secure telecommunications services in rural and remote areas. In order to bridge the existing digital divides, the policy also mandates affordable and high-quality broadband connectivity and telecom services throughout the nation. It recalled developing an ecosystem facilitating broadband and urges to work toward establishing the "right to broadband." Unfortunately, however, the policy does not recognise CNs as a resource to provide last mile connectivity.[251] The NTP also did not stress the role of CNs or public Wi-Fi services for the growth of rural Internet penetration in India.

The Universal Service Obligation Fund (USOF) in India is another ambitious scheme striving to provide connectivity to rural parts of the country. The USOF fund aims to:

---

250 National Telecom Policy – 2012. Available at http://meity.gov.in/writereaddata/files/National%20Telecom%20Policy%20(2012)%20(480%20KB).pdf.

251 Last mile connectivity is a colloquial expression widely used in the telecom and Internet industries to refer to the final segment of the networks that deliver telecommunications services to end users. More specifically, the last mile refers to the portion of the telecommunications network chain that physically reaches the end user's device or premises. For more information, see Belli (2016).

1. Incentivise telecom service providers to venture into rural and remote areas;
2. Facilitate rural roll out of infrastructure;
3. Reduce costs and, hence, end user prices; and
4. Increase the affordability of telecommunications services.

In 2016, TRAI published a recommendation paper titled "Encouraging Data usage in Rural Areas through Provisioning of Free Data"[252] in which the authority recommended the establishment of a public subsidy program to enable TSPs to provide free Internet access to rural communities, in line with the existing national frameworks. Yet again, however, the recommendation paper does not encourage community networking or rural-level ISPs to utilise the fund to provide rural connectivity.

7.5.2.1 Spectrum Policy, Regulation and Institutional Environment

Regulation of spectrum licensing, allocation, and management is characterised by policies, regulations, and laws that are elaborated, overseen and implemented by several governmental bodies. Regulations and rules governing spectrum regulation and management in India are defined by several policies and legislation, namely:

1. Indian Telegraph Act, 1885[253]
2. Indian Wireless Telegraphy Act, 1933[254]
3. Telegraph Wires (Unlawful Possession) Act, 1950[255]
4. Cable Television Networks (Regulation) Act, 1995[256]
5. Telecom Regulatory Authority of India Act, 1997[257]
6. Telecom Regulatory Authority of India (Amendment) Act, 2008[258]

252 Available at www.trai.gov.in/sites/default/files/Recommendations_19122016.pdf.

253 Available at http://www.dot.gov.in/Acts/telegraphact.htm.

254 Available at http://www.dot.gov.in/Acts/wirelessact.htm.

255 Available at http://www.indiankanoon.org/doc/980662/.

256 Available at http://www.trai.gov.in/Content/cable_television.aspx.

257 Available at http://www.trai.gov.in/Content/act_1997.aspx.

258 Available at http://www.trai.gov.in/Content/Act2001.aspx.

There are different bodies handling spectrum licensing, regulation, pricing, and the levy of penalties, and some bodies have only an advisory role. The key decision-makers on spectrum allocation and assignment include TRAI, the Wireless Planning and Coordination Wing (WPC), which is also informally known as the Wireless Planning Commission, the Department of Telecommunications under the Ministry of Communications, the Ministry of Electronics and Information Technology,[259] and *ad hoc* groups such as the Empowered Group of Ministers (EGoM) for third-generation wireless mobile telecommunications (3G) and Broadband Wireless Access (BWA) spectrum auctions.

The WPC is responsible for managing the "policy of spectrum management, wireless licensing, frequency assignments, and international coordination for spectrum management and administration of the Indian Telegraph Act."[260] The WPC has different branches, such as Licensing and Regulation (L&R), New Technology Group (NTG), and the Standing Advisory Committee on Radio Frequency Allocation (SACFA).

Importantly, the processes managed by the governmental branches mentioned above are frequently not transparent and are usually deemed as very complex and very gong by any new organisation, institution, and individual that is not already well familiarised with them. As a result, innovative uses and entrepreneurial initiatives are frequently discouraged. As an instance, the DoT takes a minimum of three months to process a letter of intent (LoI) for a new license.

7.5.2.2 National Frequency Allocation Plan

The 2011 National Frequency Allocation Plan (NFAP) forms the basis for development and manufacturing of wireless equipment as well as spectrum utilisation in the country. It contains the service options in various frequency bands for India and it also provides the channelling plan in different bands. Some of the typical frequency bands allocated for certain types of radio services in India are listed below.

259 Formerly the Ministry of Communications and Information Technology before it was dissolved in 2016 and separated into the Ministry of Communications and the Ministry of Electronics and Information Technology.

260 For more information, see http://ictregulationtoolkit.org/action/document/download?document_id=3271.

S. No	Frequency (in MHz)	Usage
1	0-87.5	Marine and aeronautical navigation, short- and medium-wave radio, amateur (ham) radio, and cordless phones
2	87.5-108	FM radio broadcasts
3	109-173	Satellite communications, aeronautical navigation, and outdoor broadcast vans
4	174-230	Not allocated
5	230-450	Satellite communications, aeronautical navigation, and outdoor broadcast vans
6	450-585	Not allocated
7	585-698	TV broadcasts
8	698-806	Not allocated
9	806-960	GSM and CDMA mobile services
10	960-1710	Aeronautical and space communications
11	1710-1930	GSM mobile services
12	1930-2010	Defense forces
13	2010-2025	Not allocated
14	2025-2110	Satellite and space communications
15	2110-2170	Not allocated
16	2170-2300	Satellite and space communications
17	2300-2400	Not allocated
18	2400-2483.5	Wi-Fi and Bluetooth short-range services
19	2483.5-3300	Space communications
20	3300-3600	Not allocated
21	3600-10000	Space research and radio navigation
22	10000	Satellite downlink for broadcasts and direct to home (DTH) services

7.5.2.3 Perspectives on Unlicensed Spectrum in India

By not requiring operators to obtain a costly license and special permission for its use, unlicensed spectrum[261] is an inexpensive and barrier-free option for meeting communications goals and requirements. Unlicensed spectrum simply refers to a spectrum band that has pre-defined rules for both the hardware and deployment methods of the radio in such a manner that interference is mitigated by the technical rules defined for the bands rather than being restricted for use by only one entity through spectrum licensing.

261 For more information, see https://www.wi-fi.org/discover-wi-fi/unlicensed-spectrum.

The Institute of Electrical & Electronics Engineers (IEEE) has defined the IEEE 802 Local Area Network (LAN)/Municipal Area Network (MAN) group of standards that include the Ethernet standard "IEEE 802.3" and the Wireless Networking Standard "IEEE 802.11." The 802.11b and 802.11g standards use the 2.4 GHz Industrial, Scientific, and Medical (ISM) frequency band, whereas the 802.11a standard uses the 5 GHz band U-NII. The unlicensed 2.4 GHz band has lately become very noisy and crowded in urban areas due to the high penetration of WLAN and other devices that are communicating and operating in the same frequency range, such as microwave ovens, cordless phones, and Bluetooth devices.

The 5 GHz band provides the advantage of less interference but faces other problems due to its nature. High frequency radio waves are more sensitive to absorption than low frequency waves. Waves in the range of 5 GHz are especially sensitive to water and surrounding buildings or other objects due to the higher adsorption rate in this range.

7.5.2.4 Licensing of Unlicensed Bands: 2.4-2.4835 GHz

According to the Indian WPC:

> Notwithstanding anything contained in any law for the time being in force, no license shall be required by any person to establish, maintain, work, posses, and deal in any wireless equipment, on non-interference, non-protection, and shared (non-exclusive) basis, in the frequency band 2.4-2.4835 GHz with the transmitter power, Effective Radiated Power (ERP), and height of antenna as namely specified.[262]

Maximum out power of transmitter	Maximum ERP	Height of antenna
(1)	(2)	(3)
1W (30 dBm[263]) in spread of 10 MHz or higher	4W (36 dBm)	Within 5 meters above of the rooftop of existing authorised building

262 Wireless Planning and Coordination Wing. (28 January 2005). 2.4 GHz notification. Retrieved http://wpc.gov.in/WriteReadData/userfiles/file/Gazette%20(%202_4%20GHz)_Outdoor.doc.

263 Decibels relative to one milliwatt.

Standard	Frequency	Mix data rate	Description
802.11a	5 GHz	54 Mbps	8 non-overlapping channels
802.11b	2.4 GHz	11 Mbps	14 overlapping channels
802.11g	2.4 GHz	54 Mbps	14 overlapping channels. Upward compatibility with the 802.11b standard.

7.5.2.5 Licensing of Unlicensed Bands: 5.150-5.350 GHz and 5.725-5.875 GHz

According to a January 2005 notification,[264] the WPC de-licensed the 5.8 GHz Band, indicating the following:

> Notwithstanding anything contained in any law for the time being in force, no license shall be required by any person to establish, maintain, work, possess, or deal in any wireless equipment for the purpose of a low-power wireless access system, including radio local area networks, in the frequency band 5.150-5.350 GHz and 5.725-5.875 GHz with the maximum effective isotropic radiated power, type of antenna, and coverage area (as specified in the table below):

Frequency band (1)	Maximum effective isotropic radiated power (2)	Type of antenna (3)	Coverage area (4)
5.150-5.350 GHz and 5.725-5.875 GHz	Maximum mean effective isotropic radiated power of 200 mW and a maximum mean effective isotropic radiated power density of 10 mW/MHz in any 1 MHz bandwidth.	Built-in or indoor antenna.	Indoor usage that includes usage within the single contiguous campus of an individual and/or duly recognised organisation or institution.

India has unlicensed and license-exempt frequency bands available for use. However, there are no light-license frequency bands for use in India. In February 1995, the Supreme Court of India declared airwaves as public property. Justices P. B. Sawant and S. Mohan

264 Wireless Planning and Coordination Wing. (28 January 2005). 5.1 GHz notification. Retrieved from http://wpc.gov.in/WriteReadData/userfiles/file/5_1%20GHz%20Notification.doc.

specified in their decision that the use of airwaves "has to be controlled and regulated by a public authority in the interests of the public and to prevent the invasion of their rights."[265]

In this context, P.K. Garg, the former wireless advisor to the Government of India, stated:

> The government had de-licensed the present bands for reasons that their de-licensing would provide a benefit to society, and the regulation of the bands through license issuance for such low-power usage by the common public would have been impractical normally. Hence, to make the decision to de-license more bands, the spectrum regulator looks at the social benefit/impact that it would make, and whether they can shift current licensed users to other frequencies if interference concerns are present.[266]

Moreover, the National Telecom Policy 2012 outlined an objective to "de-license additional frequency bands for public use."[267] It is further specified under section 4.6 of the policy that the government will "identify additional frequency bands periodically [in order to] exempt them from licensing requirements for the operation of low power devices for public use."[268] Presently, the government controls a large part of the RF spectrum, with only a minimal amount of frequencies being allocated for unlicensed use. Policy-makers, however, are beginning to recognise the importance of unlicensed spectrum.

7.6 Challenges Hampering Community Networks

A degree of ambiguity exists regarding the legal and policy governance of CNs in India. Prior to the infamous Mumbai terror attacks of 2008,[269] the use of Wi-Fi services in India was largely

265 India Together. (July 2001). "The Airwaves are the people's property." See http://www.indiatogether.org/campaigns/freeinfo/sc95.htm.

266 Personal correspondence with P. K. Garg (India).

267 Department of Telecommunications. National Telecom Policy 2012, objectives 22 and 24.

268 Department of Telecommunications. National Telecom Policy 2012, section 4.6.

269 For an overview, see https://en.wikipedia.org/wiki/2008_Mumbai_attacks.

unregulated. Today, however, there are significant regulatory obligations and licensing restrictions that are hampering the growth of public Wi-Fi services and CNs in the country.

7.6.1 Backhaul Connectivity

The biggest issue hampering the growth of CNs is lack of sufficient and cheap backhaul connectivity. India has one of the largest population densities in the world, and the demand for broadband from new users is high, which is partly owing to the availability of audio and video content via broadband. This means that there has to be a large number of Wi-Fi hubs with strong backhaul connection serving a limited number of users. At present, however, this is largely not the case, which is why most public – though not all – Wi-Fi initiatives show disappointing performance. As mentioned earlier, a robust and reliable public Wi-Fi system must be based on strong and ubiquitous fibre-optic backhaul open to all providers. This can be public infrastructure, which can be used by all providers, or a private one but with an open-access structure.

7.6.2 Spectrum Regulation

As mentioned previously, the government directly regulates a substantial portion of spectrum in India. The Supreme Court of India, in Union of India v. Cricket Association of Bengal,[270] declared that the use of airwaves "has to be controlled and regulated by a public authority in the interests of the public and to prevent the invasion of their rights."

While large spectrum bands could be appropriated and used for the public interest, such as the UHF band used for TV transmission, the scarcity of spectrum present immense challenges. So far, the approach has been to assign exclusive property rights to certain frequencies, while raising billions of U.S. dollars through spectrum auctions based on the Supreme Court's understanding of spectrum as a national resource.

---

270 1995 AIR 1236. Available at https://indiankanoon.org/doc/539407/.

However, given the advancements in transceiver technologies, such as cognitive radios, it is possible to transcend the gridlock of property rights and embrace paradigms like shared and unlicensed spectrum. Indeed, greater technology-neutral allocation of unlicensed spectrum will result in the growth of public and community wireless networks, including those built on the Wi-Fi family of standards.

7.6.3 Regulatory Restrictions

Given the complexity of spectrum regulation in India, any institution, organisation, or individual who applies for an ISP license is required to engage with many if not all the regulatory bodies detailed above. In this context, the considerable number of interested stakeholders in the licensing process leads to an increase in waiting time, unnecessary bureaucratic hurdles, and associated costs.

Hence, when NGOs, small organisations, or individuals attempt to provide last mile Internet connectivity, they either have to become a franchisee of an ISP or share their private Internet connection at their own risk. In case of the franchise model, the entity also needs to maintain the user log for which they need a local data server, which is a technically tedious task and greatly exceeding the management capability of small entities.

7.6.4 Compliance Challenges

After investigations into the Mumbai terror attacks in 2008 discovered that the perpetrators had made use of multiple unsecured Wi-Fi networks to coordinate their attacks,[271] the DoT issued a set of instructions[272] in 2009 to all ISPs operating under a Unified Access Service License (UASL), Cellular Mobile Telephone Service License (CMTSL), or Basic Service License (BSL), directing them to adhere to certain procedural mandates designed to bring greater security and accountability to the use of Wi-Fi networks within India.

---

271 "TRAI plans to prevent Wi-Fi abuse." (17 September 2008). *The Economic Times*. Retrieved from http://economictimes.indiatimes.com/industry/telecom/trai-plans-to-prevent-wifi-abuse/articleshow/3491302.cms?intenttarget=no.

272 Department of Telecommunications. (23 February 2009). "Instructions under the UASL/CMTS/Basic Service licenses regarding the provision of Wi-Fi Internet service under de-licensed frequency bands." Retrieved from http://www.dot.gov.in/sites/default/files/Wi-%20fi%20Direction%20to%20UASL-CMTS-BASIC%2023%20Feb%2009.pdf.

Among said mandates is the identity verification of Wi-Fi users either by retaining copies of their photo identification documents or by delivering login details via Short Message Service (SMS), thus retaining their phone numbers as a means of identity verification. It is important to note that these instructions issued by the DoT apply to ISPs licensed under a UASL, CMTSL, or BSL along with their franchisees, which means the ISPs are also bound by the numerous general, operational, financial, and security conditions contained therein, including but not limited to maintaining detailed registers identifying their customers, and maintaining logs of all data packets transmitted to and from customer-premise equipment.

Another pressing issue hampering the growth of public Wi-Fi services in the country is overregulation in other related areas. Under the current regulatory framework, public Wi-Fi is subject to licensing requirements, data retention, and “Know Your Customer” (KYC) policies. Even in countries with much more challenging national security concerns, the data retention and KYC policies are not so strict.

There are various stringent security and regulatory systems surrounding the entire Internet connectivity ecosystem in India. These systems are especially restrictive in certain states such as Jammu & Kasmir and may hamper the growth of Wi-Fi-based networks in those states. Access to the Internet leads to an increase in access to basic public services, including e-government services, so regulation should not restrict citizens. Therefore, relaxing regulation may have very beneficial effects regarding additional access and provision of public services that can aid in the growth and development of these states.

7.6.5 Licensing Process Challenges

As ISPs are the only entities that are eligible to apply for SACFA clearance, entities that are acting as franchisees with ISPs and may need to establish towers of more than 5 meters above the roof of a certified structure/building cannot apply for SACFA clearance. Thus, it is challenging for small organisations to provide last mile connectivity. It also creates regulatory grey areas, which can lead to prosecution under the current law.

7.6.6 Technical and Regulatory Challenges

The maintenance of Triple-A compliance[273] may also be particularly burdensome for CNs and small-sized stakeholders in general, due to the numerous technical and logistical requirements. Maintenance of Triple-A compliance requires technical support and access to data centres, which are expensive and often difficult to access from rural areas or small towns. This is an additional technical hurdle for small ISP providers who may struggle to maintain the data centre and receive high-level technical support.

As descried above, the unlicensed 2.4 GHz band has become very disturbed in urban areas. While the 5 GHz band gives the advantage of less interference, it faces other problems due to its nature.

Another challenge, confirmed by DEF's experience in particular, is the transmission of Internet connectivity from the base transceiver station (BTS) to DEF's hub station. In urban areas, even when bandwidth at the BTS is obtained, an ISP will not provide power (5-10 W) for wireless equipment or share the tower for client devices. The ISP will simply provide Ethernet out (a 10-to-30-meter Ethernet wire) and not provide any support for the further laying of cable and infrastructure.

Furthermore, maintaining a wireless Internet tower during the monsoon (rainy) season is high-risk due to severe thunderstorms, and will likely grow with the increasingly worsening effects of global climate change. It is difficult to protect wireless equipment as well, so CNs such as DEF have to maintain extra equipment along with a system backup file to restore networks, in case they are downed. This increases the burden on small ISPs, as they need to maintain extra equipment with system backup files to restore the network if needed.

Even if a small organisation provides Wi-Fi connectivity in rural areas, the purchase of a leased line from any ISP is a time-consuming process. This requires three-level coordination with all stakeholders who are providing the backhaul bandwidth, and it can take around three-to-four months or longer.

273 For more information, see https://www.w3.org/WAI/WCAG1-Conformance.

7.7 Recommendations

We have identified a set of recommendations relevant to national, regional, and international policy fora. The recommendations are detailed below.

7.7.1 National-level Recommendations

Rural/village-level ISPs should be encouraged and promoted by the government as well as by major business stakeholders. Any NGO, small organisation, or individual should be encouraged to become a rural/village ISP and be allowed to further distribute Internet connectivity.

There is a need for deregulation in order to allow anonymous access. For access through authentication, some providers may wish to have light KYC norms whereas others may choose to have rigorous KYC norms that are integrated with India Stack, etc.[274] The provider should be the entity ultimately taking the decision and, thus, deregulation is key. The most frictionless model is the unauthenticated model allowing anonymous access, followed by a light KYC regime. The model with the most friction is that with intensive KYC requirements. The existing customer login procedure requirements that have been laid down by the DoT, obliging users to provide a photo ID or to avail a one-time password (OTP) through SMS, should be abrogated for two reasons. First, it does not allow for a user to access the public Wi-Fi network without authentication, which leads to a loss of anonymity over that network when the user accesses any Internet-based service. Second, it assumes that all people will have access to mobile phones/smartphones. So far as the Indian situation is concerned, this is certainly not the case in many households where only the head of the family, who is more often than not a male member, has access to such devices. Many individuals also use much simpler devices that may not be able to receive OTPs (for example, Raspberry Pi devices). Such a requirement would, in effect, deprive a large number of individuals from accessing public Wi-Fi services and would defeat the purpose of even establishing such networks.

274 For more information, see https://indiastack.org/.

According to DoT guidelines,[275] ISPs need to pay a 15% service tax and 8% of their adjusted gross revenue (AGR). Therefore, any ISP pays 23% tax in total. We recommend that "Class C and Sub-Class C or Rural/Village" ISPs should be exempted from the 8% of AGR levy to promote last mile connectivity. We suggest the following sub-categories to consider rural/village ISPs under Class C.

Sub-class C or rural/village categories	Entry fee (in thousands of Indian rupees)[276]	PBG[277] (in thousands of Indian rupees)	FBG[278] (in thousands of Indian rupees)	Application processing fee (in thousands of Indian rupees)
Class C – 1 (Very large village)	15,000	30,000	10,000	10,000
Class C – 2 (Medium-large village)	10,000	20,000	10,000	10,000
Class C – 3 (Small villages and below)	5,000	15,000	5,000	5,000
Class D – 4 (Individual level)	3,000	10,000	5,000	5,000

According to DoT guidelines, the height of any telecommunications tower should be 5 meters from the roof of an approved building or 30 meters from the ground. If the height of the tower exceeds that, then ISPs require SACFA clearance.[279] If the aerial distance between the tower and an airport is within 7 kilometres, then ISPs also need the approval from the Airports Authority of India (AAI) – and there are other requirements in case of defence lands and borderlands. Most of these airports are in metropolitan cities. Thus, there is a need to increase the allowance for tower height to be 36 meters from the ground. We also recommend that, for

275 See the License Agreement For Unified License document for more information, available at http://dot.gov.in/sites/default/files/Unified%20Licence_0.pdf.

276 As of 18 June 2017, 100 Indian rupees (INR) equals US$1.55.

277 Performance bank guarantee.

278 Financial bank guarantee.

279 For more information, see http://wpc.dot.gov.in/sacfa_guid.asp.

towers falling within the circumference of Class-C towns, very large villages (VLVs), medium-large villages (MLVs), and small villages and below (SVs) as per the Indian Census guidelines,[280] the ISP should be allowed to gain approval from the respective municipality(ies), and the tower infrastructure should be vetted and authorised by local architect(s) and engineer(s).

Decentralised community networking allows for network managers to provide locally created and locally relevant content on the relatively high-speed intranet. Even in the event of the failure of backhaul connectivity, it would allow people access to such content due to the local storage and sharing of data. Additionally, operationalising video conferencing and voice over Internet Protocol (VoIP) services over the intranet would allow communication within the network between citizen, and similarly connected public and private institutions, such as schools, primary health centres, government offices, and others.

De-licensing spectrum would lead to innovation and entrepreneurship, stimulated by fewer regulatory barriers. This could also lead to lowering the costs of mobile service data plans due to increased competition.[281] The approach for de-licensing spectrum should also be technology neutral and must find a balance between proprietary, unlicensed, and shared spectrum. Other spectrum-related recommendations include:

- Utilising frequencies in the 6, 11, 18, 23, 24, 60, 70, and 80 GHz bands to facilitate replicating examples like Webpass (United States), which has radios capable of delivering up to 2 gigabits per second (Gbps), both upstream (upload) and downstream (download).[282]

---

280 For further information, see http://censusindia.gov.in/Data_Products/Library/Indian_perceptive_link/Census_Terms_link/censusterms.html

281 Milgrom, P., Levin, J., & Eilat, A. (2011). "The case for unlicensed spectrum," Retrieved from: https://web.stanford.edu/~jdlevin/Papers/UnlicensedSpectrum.pdf

282 "Webpass buildings have radios capable of delivering up to 2 Gbps, both upstream and downstream. Anything beyond 5,000 meters will still work but you lose bandwidth...Webpass radios operate in many different frequencies, including the unlicensed 2.4 GHz and 5 GHz bands used by Wi-Fi, Barr said. Webpass also uses the 6, 11, 18, 23, 24, 60, 70, and 80 GHz bands. These include a mix of licensed and unlicensed frequencies." See Brodkin, J. (18 June 2015). "500 Mbps broadband for $55 a month offered by wireless ISP." *Ars Technica*. Retrieved from: https://arstechnica.com/information-technology/2015/06/500mbps-broadband-for-55-a-month-offered-by-wireless-isp/.

- Frequencies in the 5.15-5.35 GHz bands as well as the 5.725-5.775 GHz bands are unlicensed for indoor-use only. These bands should be unlicensed for outdoor use as well in order to facilitate the creation of wider wireless communication networks and the use of innovative technologies.
- There should be more unlicensed spectrum in the 2.4 GHz range, beyond what is already unlicensed, for the expansion of wireless communication networks.
- The 1800-1890 MHz band, which is earmarked for the operations of low-power cordless communication in India, should be unlicensed in line with international practices. Many bands for this use have already been unlicensed in Europe and the United States.[283]
- 50 MHz in the 700-900 MHz band, earmarked for broadcast, should be made available to better utilize available spectrum. Almost 100 MHz is currently unused in most parts of the country.

7.7.2 Regional and Global Recommendations

In terms of regulatory measures, there should be minimal and proportionate regulation – *i.e.*, the regulation of entities involved in the provision of public Wi-Fi networks should be based on their capacity to harm the public interest and/or individual rights. By this we mean that only public Wi-Fi networks that have a large number of users (e.g., more than 5,000 individual users) should be subject to any regulation. Small-scale/public Wi-Fi/community-based network providers, like public Wi-Fi networks in small villages or apartment complexes, should be left to self-regulation. Regulatory burdens, which serve no purpose, only deter these providers from providing such services at all.

Regulation must be technology neutral, and should focus on the entities using these technologies, which can unlock good or causing harm. This neutrality should be reflected in the name of the policy – *i.e.*, "community networking policy," and not "community Wi-Fi policy." The current definition of Wi-Fi is closely coupled

283 For more information, see https://cis-india.org/telecom/unlicensed-spectrum-brief.pdf

with certain frequencies, and public wireless networks should be promoted regardless of technology and specific frequency bands.

Stakeholders should promote, disseminate, and support the CN model through their existing dissemination channels, networks, and governance processes. Create a more conducive regulatory environment by making more unlicensed spectrum available – particularly in those bands that are allocated nationally, but not used in rural areas, such as TV, GSM, *etc*. This includes implementing measures to reduce the backhaul costs such as more open access fibre-optic national networks, and reducing the fees and taxes to import and use telecommunications equipment.

USOF, a Universal Service Funds (USF), and other funding mechanisms should be available for the deployment, operation, maintenance, and scaling of CNs.

Governments, NGOs, and related organisations, such as development organisations or Internet-related organisations, should provide more support for training and capacity building among CN members, especially since many of the CN professionals interviewed stressed that, while they do provide technical and operational training, they lack business and managerial training.

Governments should focus on greater engagement with CNs and initiate dialogue processes and relationship building, especially since CNs want to add value to communities, and many governments are under pressure to expand Internet access and deliver services. According to the community networking professionals we interviewed, engagement with governments received mixed results. Multistakeholder cooperation and engagement should be considered a key priority.

7.8 Annex: Semi-structured interview rubric

1 Does your country have specific policies that support community networks (CNs)?

  a If yes, can you describe them and provide us with links to them if they are publicly available.

2 What are the legal and business challenges related to spectrum allocation in your country?

3 Do any spectrum management mechanisms exist in your country?
   a If yes, what are they and what are their challenges?
      i. For example, does your government publish its spectrum allocations and assignments?
      ii. Does your country hold open proceedings with respect to new and innovative uses of spectrum, including experimental licensing?

4 Does your country allow unlicensed use of spectrum or spectrum sharing or secondary use of spectrum?
   a If yes, when were these policies put into place?

5 Does your country allocate specific spectrum for community networks?
   a If yes, what are they?

6 What are the spectrum licensing processes in your country? Please define or provide us with a link to the process.

7 Are community networks allowed to set-up/operate a network in your country, or are there specific policies or regulations that are specific to community network set-up or operations?

8 Do community networks need an authorisation or a license to exist in your country?
   a If yes, what entity provides those licenses or authorisations and how long does the process take on average.

9 Does your team conduct training?
   a If yes, what type of training?

10 Has your team had business and management training to sustain your CN?
   a If yes, was it local training?

11 Do you work with local and national authorities to make them aware of CNs and the difference they make in your local community(ies)?

7.9 References

Baig, R., Roca, R., Freitag, F., & Navarro, L. (2015). Guifi.net, a crowdsourced network infrastructure held in common. Computer Networks, 90, 150-165.

Belli, L. (Ed.) (2016a) Community Connectivity: Building the Internet from Scratch Annual Report of the UN IGF Dynamic Coalition on Community Connectivity. http://tinyurl.com/comconnectivity

Belli, L., Echánz N. and Iribarren G. (2016). Fostering Connectivity and Empowering People via Community Networks: the case of AlterMundi. In Belli L. (Ed.) 2016a

Brodkin, J. (18 June 2015). "500 Mbps broadband for $55 a month offered by wireless ISP." Ars Technica. Retrieved from: https://arstechnica.com/information-technology/2015/06/500mbps-broadband-for-55-a-month-offered-by-wireless-isp/

Butler, J. (2013). Wireless Networking in the Developing World. 3rd Edition. http://wndw.net/download/WNDW_Standard.pdf

Clarke, R. N. (2014). "Expanding mobile wireless capacity: The challenges presented by technology and economics." Telecommunications Policy, 38(8–9), pp. 693-708. http://www.sciencedirect.com/science/article/pii/S0308596113001900

Center for Neighborhood Technology. (2006). Community Wireless Networks: Cutting Edge Technology for Internet Access (Rep.). http://www.cnt.org/sites/default/files/publications/CNTCommunityWirelessNetworks.pdf

de Rosnay, M. D. (Ed.). (2016). *Network infrastructure as commons: Alternative communications networks throughout history*. Net Commons. http://netcommons.eu/sites/default/files/d5.1_history_v1.1.pdf

Department of Telecommunications. (23 February 2009). "Instructions under the UASL/CMTS/Basic Service licenses regarding the provision of Wi-Fi Internet service under de-licensed frequency bands." http://www.dot.gov.in/sites/default/files/Wi-%20fi%20Direction%20to%20UASL-CMTS-BASIC%2023%20Feb%2009.pdf

ECC (Electronic Communications Committee within the European Conference of Postal and Telecommunications Administrations). (2009) Light Licensing, Licence-exempt and CommonsECC Report 132. Moscow. http://www.erodocdb.dk/Docs/doc98/official/pdf/ECCRep132.pdf

Elkin-Koren, N. (2005). Making technology visible: liability of internet service providers for peer-to-peer traffic. NYUJ Legis. & Pub. Pol'y, 9, 15.

ET Bureau. (2008, September 17). TRAI plans to prevent WiFi abuse. Retrieved 2017, from http://economictimes.indiatimes.com/industry/telecom/trai-plans-to-prevent-wifi-abuse/articleshow/3491302.cms?intenttarget=no

Idachaba, F. E. (2017, March). Spectrum bundling architectures for increased traffic capacity in mobile telecommunication networks. In Proceedings of the International Multiconference of Engineers and Computer Scientists, Vol II. http://www.iaeng.org/publication/IMECS2017/IMECS2017_pp624-627.pdf

India Together. (2001, July). The airwaves are the people's property: The Supreme Court ruling of 1995. http://www.indiatogether.org/campaigns/freeinfo/sc95.htm

Internet Governance Forum (IGF) (2016). Policy Options For Connecting & Enabling The Next Billion(s): Phase II (2016 edition).

Internet Society. (May 2017). "Supporting the creation and scalability of affordable access solutions: Understanding community networks in Africa". https://www.internetsociety.org/sites/default/files/CommunityNetworkingAfrica_report_May2017_1.pdf

Longford, G., & Wong, M. (2007). Spectrum policy in Canada: A CWIRP background paper. Community Wireless Infrastructure Research Project. www.cwirp.ca/files/CWIRP_spectrum.pdf

Manzar (2014). Rs70,000 crore budget, and not even 70,000 connected? In:Livemint. http://www.livemint.com/Opinion/FcGsXzS4Vho8OIpKf3V9aN/Rs70000-crore-budget-and-not-even-70000-connected.html

Milgrom, P., Levin, J., & Eilat, A. (2011, October 12). The Case for Unlicensed Spectrum. https://web.stanford.edu/~jdlevin/Papers/UnlicensedSpectrum.pdf

Pawar, B. L. (February 23, 2009). Instructions under the UASL/CMTS/Basic Service licenses regarding the provision of Wi-Fi Internet service under delicensed frequency bands (No 842-725/2005-VAS) (India, Ministry of Communications & IT, Department of Telecommunications). New Delhi.

TRAI. (2016). Consultation Paper on the Proliferation of Broadband through Public Wi-Fi Networks (India, Telecom Regulatory Authority of India (TRAI)). Retrieved 2017, from http://www.trai.gov.in/sites/default/files/Consultation_Note_15_November_2016.pdf

WPC. (January 28, 2005). 5.1 GHz Notification (India, Wireless Planning and Coordination Wing). Retrieved 2017, from http://wpc.gov.in/WriteReadData/userfiles/file/Gazette%20(%202_4%20GHz)_Outdoor.doc

Saldana, J. *et al.* (2016). RFC 7962. Alternative Network Deployments. Taxonomy, characterisation, technologies and architectures, Working Group Document in the IRTF GAIA (Global Access to the Internet for All) group. Aug. 2016. https://www.rfc-editor.org/info/rfc7962

The Economic Times. (17 September 2008). TRAI plans to prevent Wi-Fi abuse. http://economictimes.indiatimes.com/industry/telecom/trai-plans-to-prevent-wifi-abuse/articleshow/3491302.cms?intenttarget=no

8 Community-led Networks for Sustainable Rural Broadband in India: the Case of Gram Marg

Sarbani Banerjee Belur, Meghna Khaturia and *Nanditha P. Rao*

Abstract

To bridge the digital divide facing rural India, a cost-effective technology solution and a sustainable economic model based on community-led networks is needed. Gram Marg Rural Broadband project at IIT Bombay, India has been working on both these aspects through field trials and test-bed deployments. It has been studied that even if the connectivity reaches rural India, without a sustainable economic model, the network would not be able to sustain itself at the village level. Our impact studies have revealed the need for community owned networks. The study reveals that villagers understood that they could save time and money with Internet connectivity at the village. However, the network was not sustainable and, for this reason, villagers suggested community-led networks would enable them to 'own Internet'. Hence, a Public-Private-Panchayat Partnership (4-P) model was developed. In this partnership model, the Panchayat, which is the local self-government structure at the village level, takes ownership of the network. The partnership enables the network to be community-led for effective decision making and giving priority to development of services based on village needs. The public-private partnership enables Internet connectivity to reach the village from where it is taken over by the Panchayat. The investment for the network is done by Panchayat at the village level. Local youth known as Village Level Entrepreneurs (VLEs) invest, maintain the network and generate revenue. The model ensures a decent and sustainable Return-on-Investment for the Panchayat and nominal user subscription cost. It also considers expected future growth in demand and related cost dynamics. Revenue generation and sharing is an important aspect which provides incentive for Internet's spread and expanse in the village.

8.1 Introduction

One of the crucial factors which can contribute to economic growth and development in rural areas is the broadband connectivity. Several activities such as banking, e-governance, e-learning, tele-health services and activities to empower villagers with e-commerce can be promoted by enabling them digitally. Internet connectivity in the village will also help in creating entrepreneurs and generate employment opportunities within the village. Social networking and entertainment are added benefits of the Internet. However, providing Internet connectivity to rural areas in India is a tough task in itself, due to several reasons. Some of the important challenges are i) lack of digital awareness, ii) unaffordability and iii) lack of Internet infrastructure. Due to villagers being digitally less aware, they are unable to appreciate the benefit of Internet and thus the Internet demand in these areas is limited. Even if there is demand, the nature of demand is dependent on their income and is sporadic. Lack of Internet infrastructure is another important challenge in these areas. The capital expenditure and operational costs of setting up a 3G/4G network is generally very high. Sparse population and low to medium subscriber density makes it impossible for them to get a return on their investment. Hence, penetration of operators in these rural areas is low to none. Other added challenges such as lack of fibre, difficult terrain and scarcity of electricity makes it impossible to connect these areas.

To bridge this digital divide, Government of India under its BharatNet initiative[284] is building an information highway by connecting village local self-government offices called Gram Panchayats (GPs) through optical fibre. This initiative, though began in the year 2012, will take a long time for completion and aims to connect only the GPs. Thus, the villages situated a few kilometres away will remain unconnected. Furthermore, even if connectivity would reach the villages in India, it would be difficult to sustain connectivity at the village level without a sustainable economic model.

284 See BharatNet Status http://www.bbnl.nic.in/index1.aspx?lsid=570&lev=2&lid=467&langid=1

In this paper, we discuss a potential solution to the above-mentioned problem. Gram Marg's Rural broadband project at the Department of Electrical Engineering, IIT Bombay[285] aims to connect the unconnected by overcoming barriers to connect rural India. In order to provide ubiquitous connectivity to these areas, a shift is required from traditional technology to a more affordable, efficient and robust technology. A wireless solution based on TV White Space has been experimentally proved to be an effective solution to connect the rural areas. In India, there is a significant amount of available spectrum in the TV band which is largely unutilised. In addition to this, the TV band has good long-distance propagation characteristics along with non-line-of-sight characteristics that make connectivity feasible in these areas. Under the auspices of the Gram Marg project, two large scale test-beds have been deployed. The first TV White Space test-bed in India[286] covering seven villages to test the feasibility of TV White Space technology was set up by Gram Marg. In the second test-bed we scaled it up to 25 villages. Unlike the first test-bed, the technology approach to connect these villages also uses point to point 5.8 GHz link in the unlicensed band. Gram Marg's aim is not only to develop technology solution for rural broadband in India, but also develop a sustainable economic model around the proposed technology for its viability.

The main objective of this paper is to propose an economic model and its implementation towards sustainability for rural settings in India. To design a sustainable model, two important criteria needs to be taken into consideration. The first thing to ensure is that, there is decent and sustainable Return-on-Investment (ROI) for the investor and secondly, a nominal user subscription cost for the end user. However, due to disparity in the demand-supply dynamics in the rural areas, developing a sustainable model becomes a challenging task in itself. On one side, the cost for setting up a network is high, whereas, on the other, the

285 See Gram Marg Website http://www.grammarg.in/

286 Kumar et al (2016).

demand is low to none. We suggest Community Networks (CNs) as a plausible solution to ensure sustainability at the village level. Community involvement will influence effective decision making and prioritising services based on the village needs. The CN model that we suggest in this paper is based on a Partnership model which involves Public sector, Private sector and the Panchayat. For this reason, this model is termed as 4-P model.

The paper is organised as follows. The first section of the paper discusses the motivation for addressing the need for sustainable model in rural broadband. In the second section we shall discuss existing economic models and their shortcomings. In the third section, we will discuss the 4-P model in detail. Finally, we will conclude the paper with recommendations and policy implications.

8.1.1 Motivation

Learnings from Gram Marg's test-beds provided insights on two important things for rural broadband project to be successful. These are i) need for a cost-effective technology and ii) need for a sustainable economic model. We will discuss this next.

8.2 Technology

The technology requirements in rural areas are quite different than those in urban areas. Hence, there is a need to develop a technology based on requirements of rural areas. The technology options for connecting rural India needs to be cost effective, easy to deploy, suitable for hilly terrain and dependent on renewable energy sources like solar and wind. In general, all rural connectivity projects deploy standard Wi-Fi technology (5.8 GHz and 2.4 GHz) in the license exempt band. While 5.8 GHz is used for backhauling Internet, 2.4 GHz is used in access points in Wi-Fi hotspots. This technology uses off the shelf devices which can be easily bought in the market. However, some of the disadvantages of this technology is that, it works in strict Line of Sight, requires large heighted towers and has a small coverage area.

Gram Marg proposes a wireless solution based on TV White Spaces (TVWS) for connecting rural India[287]. There is a significant amount of TV White Space available in the UHF band (470-590 MHz) in India with Doordarshan being the only terrestrial TV broadcaster in this band. Currently, there are no regulations for the usage of TV White Spaces in India. According to the National Frequency Allocation Plan (NFAP) 2011, fixed and mobile services can be permitted in 470-585 MHz band on case by case basis. For setting up a test-bed, there is a requirement of experimental test license to be procured before deploying the technology on ground.

TV UHF band has very good propagation characteristics which works even in NLoS (Non- Line of Sight) condition. Thereby, connecting villages that are located at far off distances from each other with sparse population. Also, the power requirements of this technology being low, makes it a perfect suit for connecting the rural areas with alternative energy sources like solar energy. It should be noted that these areas have intermittent power supply and harnessing options like solar energy and wind energy will bring down the overall cost of the network. Solar energy has been used as renewable energy source for the TV White Space test-bed. Another advantage of this technology is its ability to effectively work with towers of low height. Tower cost is a major part of the capital expenditure in setting up a network. To bring down the cost, we have fixed the height of the towers to be 9-10m in our test-bed. We have also used already existing de-functional towers to further reduce the investment cost.

Gram Marg team is also working on technology development of TVWS devices alongside testing their feasibility of implementation and deployment on ground. The TVWS device has been designed and fabricated in the Gram Marg lab. These devices are in the prototype stage, undergoing experimentation.

8.3 Impact Assessment Study

The authors of this paper studied the impact of providing Internet connectivity to the test-bed villages for a duration of one year. The

287 See Khaturia, Belur, Karandikar (2017).

study suggested that, if the villagers are digitally aware and can avail Internet to use e-Governance services in their own village, they do not mind paying for the Internet. By availing services in the village, the villagers save time and money which they would have otherwise spent visiting the block headquarters to access the e-Governance services. We also tested the villagers' readiness to pay for Internet. Given the situation that these villages had no Internet connectivity, the villagers calculated the total amount which they saved from not travelling to the block headquarters. They then back calculated a fixed amount of INR 150 (approx. 2 US dollars) monthly that they would save from not travelling and they could spend to afford Internet in their village. However, without a sustainable economic model at the village level, the Internet connectivity even though reached the villages, was not able to sustain itself in the village.

The two important players in the three villages that we studied were a private telecom operator who provided bandwidth and a government office (Gram Panchayat office) that "housed" the Internet, providing access points. Two important conclusions derived from the impact study were, first, the need for a sustainable model wherein the village would own the network and, second, the benefits of involving the Panchayat (local self-government) to run the network at the village level. It was observed that involvement of the community can be an important factor in developing a sustainable model. CNs can motivate villagers to have an ownership of the network, thus enabling maintenance of the network at the village level. Also, the community acts in coalition to decide what are the services that a particular village needs and should be prioritised, depending on their local needs. For example, a village where inhabitants walk several km to avail banking services, would need e-banking services as a priority. In another case, a village with high malnutrition deaths need primary health care facilities as a priority.

8.4 Existing Economic Models

Customer base and Return-on-Investment are the two driving factors leading to success of traditional business models of Internet connectivity. It is obvious but natural that these two factors are available in urban areas and not in the rural areas. Hence, to motivate operators to reach rural areas, there has to be innovation both in technology as well as business strategy. However, it should be noted that a single business strategy will not be suitable for all rural scenarios. We should take into account the sentiments and needs of the people in these areas while developing a business model. For instance, in certain locations there could be a resistance to adoption of Internet due to harmful effects of radiation, while in other locations, lack of digital awareness is the reason for no demand for Internet.

Providing connectivity to remote rural areas in the last decade has been an important topic of research. Many business models have been proposed in India, offering unique approaches to overcome the challenges in connecting rural areas. Some of the models will be discussed here along with their merits and demerits.

ITC eChoupal[288]

Launched in the year 2000, this is one of the oldest and largest initiative to bring about Internet based interventions in rural India. This initiative is unique and innovative, as it contributed substantially to the rural economy by co-creating rural markets with the help of local communities. Due to farms being fragmented, farmers took resort to the 'middle man' for selling and buying farm produce. ITC's eChoupal Internet intervention helped in overcoming this challenge by setting up 6450 kiosks in 40,000 villages and reaching out to 400,000 farmers. Farmers could enhance their farm productivity and hence could get higher farm gate prices for their produce. Connectivity was provided to the farmers through phone lines or Very Small Aperture Terminal (VSAT). This initiative though helpful for the farmers, could not sustain itself for a long duration due to policy issues, export bans, subsidies and slow amendment to Agricultural Produce Market Committee (APMC) Act. This being an Internet intervention for rural farmers, the bandwidth requirement was only meant to cater a single service. Another reason why the project stopped

288 Bowonder, Gupta, Singh ([s.d.]).

scaling itself was due to its inability to effectively combine other services along with farm applications to serve the communities based on their needs.

Air Jaldi[289]

Air Jaldi is an Internet Service Provider (ISP) providing broadband to enterprises and individuals in India. Air Jaldi uses fixed wireless access in the license exempt band (5.8GHz) and has built 10 networks in 6 different states of India. Air Jaldi's business model revolves around employing low cost technology and involving local youth for the operation and management of the network. Partnerships with government organisations, Ford Foundation, Facebook and Microsoft have played a major role in Air Jaldi's success. As the networks set up by Air Jaldi are dependent on existing infrastructure, their outreach is limited to only those areas where infrastructure is available. Though it is a successful initiative, adherence to local needs and dependency on external funding can act as a bottleneck in its scalability.

Wireless for Community Network (W4C)[290]

Wireless for community network (W4C) is an initiative of Digital Empowerment Foundation (DEF) and Internet Society (ISOC). W4C was launched in 2010 with the aim to connect rural areas where communities are well established such as tribal areas. In order to connect these communities, W4C employs low cost Wi-Fi equipment in the license exempt band (2.4 and 5.8 GHz) to set up their network. This initiative uses a bottom-up approach wherein community is an important stakeholder in the operation and management of the network. W4C has set up networks in tribal communities such as Baran and Tilonia in Rajasthan, Guna and Shivpuri in Madhya Pradesh and Agariyas in Rann of Kutch, Gujarat.

Through their contributions, the above-mentioned initiatives have paved the way for new innovations to come about. Although these

289 See https://airjaldi.com/

290 See http://wforc.in/

initiatives have succeeded at a small scale, by serving specific communities, it is important to note that they face challenges during their scaling up phase, due to unavailability of funds, partnerships and regulatory restrictions. Thus, it can be argued that there is a need for innovative economic models, for large-scale penetration of Internet in India.

8.5 Public-Private-Panchayat Partnership (4-P) Model

The Public-Private-Panchayat Partnership (4-P) model has been developed by Gram Marg, based on user feedback from field trials and impact assessment study. To take broadband connectivity to the rural areas of India, partnerships have always been the prescribed method. The most relevant of these partnerships have been the Public-Private partnerships (3-P model). However, these partnerships are frequently unable to sustain themselves, due to their demerits, such as planning and maintenance delays, inadequate monitoring, funding gaps and improper risk management. The merits and demerits of Public-Private partnerships are described in Fig.1. An example of the inefficiency of the 3-P model is offered by BharatNet to connect 250,000 Gram Panchayats in India. Although this initiative started in 2011 is still lagging behind in achieving its projected goals. Furthermore, the GPs that are already “connected” are unable to access the broadband, unviable business model being one of the important reasons.

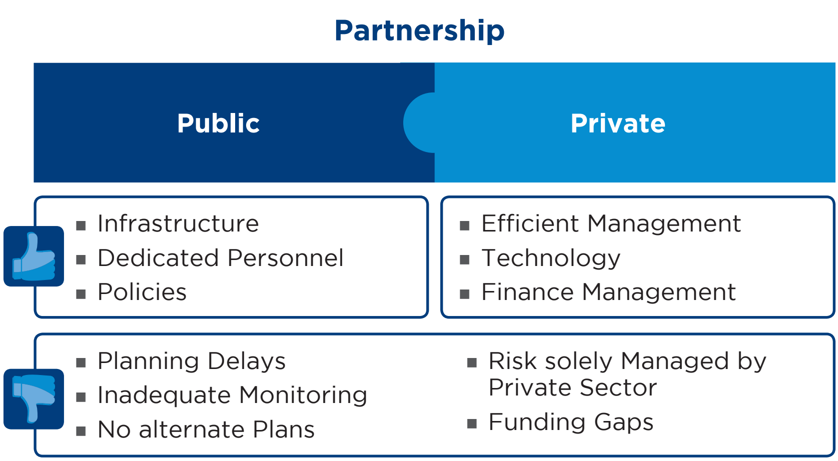


Figure 1. Public Private Partnership

A classic feature that is commonly found in partnership models studied so far is the adoption of a top-down approach. In this approach, the involvement of local people for whom the network is being set up and he consideration of the local needs are not taken into account. For example, in rural areas which suffer from maternal, child and infant deaths, the connectivity services should be oriented towards better healthcare facilities.

In order to build a network that can cater to local and regional needs, we follow a bottom-up approach and propose a sustainable economic model based on CNs. Unlike, some of the existing CNs in India, which are based on established communities such as tribes, or communities of individuals sharing specific occupation, or caste *etc.*, the type of CN analysed here is different as it relies on and forms communities based on usage and adoption of Internet, thus bridging existing gaps, by default. This proposed model is based on a Public-Private-Panchayat Partnership (4-P) as illustrated in Fig. 2. Notably, in this model:

- The Panchayat holds the responsibility of maintaining the network at the village level by appointing Village Level Entrepreneurs (VLEs). The Panchayat also plays a major role in defining priorities for the local digital needs of the villagers.
- The Private partnership plays a vital role regarding technology innovation and setting up of the network.
- The Public partnership is important for the viability gap funding and making suitable policy recommendations to the government.

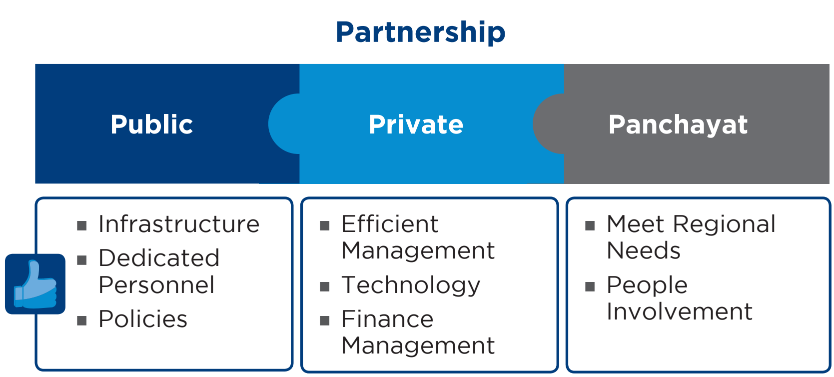


Figure 2. 4-P Model

8.5.1 Conceptualising Viability of 4-P Model

Analysing cost dynamics is very important for conceptualising the viability of the 4-P model. Two important cost indicators that are taken into account for deploying a network are Capital Expenditure (CAPEX) and Operational Expenditure (OPEX). In order to bring down the total cost of the network, innovation in technology plays an important role. Moreover, dependency on single technology for network growth and expansion may not be feasible in the rural settings of India. Hence, it is proposed that existing technologies and innovation be optimally mixed to form a true game changer for the Indian rural connectivity scenario. This will enable large outreach and will prove to be a very cost-effective solution when scaled up.

Insights from Gram Marg test-beds suggests that it is important to exploit the benefits of various technologies to bring down the overall cost. For instance, in locations where tower infrastructure is already available, Wi-Fi (5.8 GHz) is a more suitable option. Whereas, in locations devoid of any infrastructure, TVWS is much more feasible due to its dependency on low heighted towers, less power consumption making it a cost-effective solution for rural broadband.

Revenue generation and revenue sharing is also an important aspect that contributes to sustainability of the 4-P model where a large part of the revenue goes to the VLE, which in turn motivates them for extending the network inside the village. In the proposed 4-P model, this aspect is brought about by the involvement of local youth in the village known as Village Level Entrepreneur (VLE). VLEs invest and maintains the network as well as generates revenue by selling bandwidth to the villagers. VLEs are also instrumental in taking the eGovernance services to the end users and in turn generates employability for themselves, thus making the model sustainable. The revenue generated is also shared between the partners depending upon their contribution in the partnership.

The authors of this paper believe that all the aspects mentioned above, if carefully taken into account, can lead to a positive Return-on-Investment (ROI) or cost benefit for the investor. This suggests that the model will perform well on field and is also a lucrative value for the investment made.

8.6 Policy Recommendations

We suggest the following policy recommendations to ameliorate the rural connectivity scenario in India.

- CNs are allowed to operate in India but there are no specific policies that support these networks. We suggest that CNs should be promoted and encouraged by the government.
- Different marketing strategies can be adopted by local ISPs such as advertising, branding of products, subsidies, discounts *etc*. This would enable innovation and competition leading to better quality of services in rural areas. Such provisions should be taken into account while designing the policies for CNs.
- CNs should always be decentralised as they will enable locally created and locally relevant content to be circulated in the villages for better acceptance of Internet.
- To scale the CNs, funding should come through funding agencies like Universal Service Obligation Funds.
- As suggested above, usage of TVWS is crucial in making the network cost-effective in comparison to other technologies. However, there are no regulations in India for the usage of TVWS for rural broadband. We suggest that TVWS spectrum should be lightly licensed in semi-rural areas. In remote areas where there is no penetration of ISPs, this band should be license-exempt.

8.7 Conclusions and Future Work

In this paper, we address two questions that are very pertinent to the longevity of broadband in rural areas of India. The first is related to why sustainability of rural broadband in India is necessary and the second is how rural broadband can perpetuate itself in these areas where the demand-supply dynamics is so uneven.

Hence, we propose a sustainable economic model termed as 4-P model, developed by Gram Marg and based on the utilisation of CNs as a solution. The 4-P model suggests partnership between Public, Private and Panchayat. The model is based on insights and findings from Gram Marg test-beds and adopts a bottom-up approach. Before elaborating the 4-P model, existing partnership models have been reviewed and various approaches to overcome the challenges in serving rural India have been studied. In the 4-P model, the Panchayat is at the crux of the model, enabling local participation and regional needs being met. Village youth are appointed as Village Level Entrepreneurs (VLEs) who invest, maintain and operate the network in the village. They are also responsible for expanding the network in the village. Importantly, cost is an significant aspect of this model. In order to cater to rural needs, the model has to be based on cost-effective technology solutions that can bring down the cost of setting up the network substantially. Hence, it is proposed that an optimal mix of technologies along with innovation can be utilised as a game changer for rural connectivity scenario in India. Through revenue generation and sharing, the model would be able to sustain itself in the rural areas. This paper also discusses the need for policy formulation for developing CNs in India. This body of policy is currently not present in India, although CNs and their development in India would be crucial for rural connectivity to reach remote rural areas.

Currently, the 4-P model is at its validation phase on the field in Gram Marg's 25 villages live test-bed at Palghar, Maharashtra. As part of the validation, we expect to perform extensive cost benefit analysis to quantify sustainability of Internet, cost effectiveness of technologies, revenue generation by VLEs and calculation of Return-on-Investment. The success of the model will be measured through a set of success indicators. Both qualitative and quantitative data would be collected from the network set up at the live test-bed. The data will be related to demand, quality and affordability by which the sustainable economic model can be tested for its viability.

8.8 References

Bowonder, B., Gupta, V., Singh, A. ([s.d.]). Developing a rural market e-hub. The case study of e-Choupal experience of ITC. *Rural Market e-Choupal*, [s.d.]. Available at http://www.planningcommission.gov.in/reports/sereport/ser/stdy_ict/4_e-choupal%20.pdf.

Khaturia, M., Belur, S. B., Karandikar, A. (2017), "TV White Space Technology for Affordable Internet Connectivity in Developing countries", In, `TV White Space Communications and Networks', Eds: Robert Stewart, David Crawford and Andrew Stirling, Elsevier Publications (In Press).

Kumar, A. et al (2016). "Toward enabling broadband for a billion plus population with TV white spaces," *IEEE Communications Magazine*, July 2016.

9 Comparing Two Community Network Experiences in Brazil

Bruno Vianna

Abstract

This paper describes two installations of community networks in Brazil in two different environments. The first, completed in 2015, took place in the rural village of Fumaça. It was enabled by a grant from Commotion Wireless and built by a team of volunteers together with the community. The network remains operational with free and open access to date as of the time of writing. The second one was completed in the Maré complex, a huge concentration of favelas in the city of Rio de Janeiro. It was made possible through an open call for workshops from the Rio de Janeiro state government, and was executed by the students who participated in the week-long course – many of them from the favela. The two cases provide interesting information regarding the potential for community networks in the global south.

9.1 Introduction

This article aims to present a comparison of two Community Network (CN) installations in Brazil: in a countryside village with less than a thousand inhabitants, and the other in one of Rio de Janeiro's largest favela (low-income urban slum) conurbations, *Complexo da Maré*.

The intention behind examining these initiatives side-by-side is to compare the difficulties and opportunities in two very different scenarios. The rural setting had no communications services and a more reduced community, while the urban neighbourhood had numerous competing Internet Service Providers (ISPs) and a much sparser set of participants. Yet, in both cases analysed, it was soon evident that, if every community had had the ability and knowledge necessary to take advantage of local characteristics, they could have developed and offered an ample range of services and solutions.

9.2 The Fumaça experience

Nuvem[291] – the Rural Station for Art and Technology – is the institution responsible for the installation of the CN in Fumaça. Nuvem has been running since 2011 in the Serra da Mantiqueira mountain range between São Paulo and Rio de Janeiro. It is a space that mixes activities such as artistic residencies, activism, and the development of technologies to promote autonomy. With this goal in mind, Nuvem hosted two meetings dedicated to collaborative production called Interactivos in 2012 and 2013.[292] During the second meeting, one of the projects selected was the development of a CN, proposed by Al Cano[293] from the Guifi.net[294] network, in Spain. Although his idea was to jumpstart a local network, the research project was more successful than the practical one.

Fumaça[295] is a rural district in the municipality of Resende, home to less than a thousand people. The urban area has about 120 houses on 10 streets. It is located about 30 kilometres from the city of Resende, 12 of which is nothing but dirt road. It is also where Nuvem holds some of its activities, on a farm called Nebulosa. Having visited the place before, in 2015, Al Cano proposed to submit an application for a grant from Commotion Wireless,[296] an institution dedicated to the development and diffusion of mesh networks and CNs, maintained mainly by the Open Technology Institute.[297] The call offered a US$10,000 grant to build the network.

The plan was to host experts and volunteers for a week, when they would teach and help locals install and maintain the network. The budget included funds for 16 TP-LINK WDR3500 Wi-Fi routers, two Ubiquiti Rocket M5 long-distance 30dBi parabolic antennas, accessories such as poles, Power over Ethernet (PoE) electricity supplies, pigtail extension cords for antennas, weather boxes for the routers, and a PC that would work as a local server. Transportation

291 See http://nuvem.tk
292 See http://nuvem.tk/wiki/index.php/P%C3%A1gina_principal#Laborat.C3.B3rios
293 See http://nuvem.tk/wiki/index.php/Redes_livres
294 See http://guifi.net
295 See https://pt.wikipedia.org/wiki/Fuma%C3%A7a_(Resende)
296 See https://commotionwireless.net/
297 See https://www.newamerica.org/oti/

and meals were also paid for the collaborators and volunteers. All experts and volunteers coming to participate to the meeting were to camp out at the Nebulosa farm for the duration of the activity. A GSM mobile phone network was also planned and installed, although this later installation is not covered in this paper.

Although Commotion Wireless has its own brand of mesh firmware, the grant rules did not require us to use it. Thus, the technology we chose for mesh networking was LibreMesh,[298] which was developed in part by Guifi.net and by some of experts who participated in the installation. However, it is important to emphasise that the establishment of a successful CN depends mainly on the involvement of the locals and their interest in getting it to work. The fact that Nuvem was based in the community where the CN was going to be developed helped ensuring a close connection between the community needs and wishes and what was going to be technically implemented. His connection was also favoured by the active participation of the local inhabitants who took part in the conception and implementation effort. Notably, in 2014, several community meetings took place due to a state government project to protect water sources in the area. These meetings included polls to identify the most immediate needs of the population, where telecommunications infrastructure was ranked the highest, as Fumaça had no landlines or cell phone coverage. A public Wi-Fi hotspot installed in the main square slightly mitigated the situation, but many villagers did not know how to use the Internet (or lacked devices to connect at all). Moreover, having to physically reach the central square was not a practical solution for villagers, notably during the rainy season, or for youngsters that needed Internet access to access information essential for educational purposes and for which studying in a public square was not a viable solution. This access point, though, would be a useful and strategic element for the proposed CN.

During the last amongst the meetings mentioned above, the CN project was announced, calling for the following gatherings, which would be themed around the installation of a Wi-Fi Internet access network managed and maintained by the community. From the

298 See http://libremesh.org/

beginning, it was made clear that there would be no costs for the users since the equipment was donated and the connection used would be provided by the city, through the connection of the existing hotspot in the main square. It is important to stress that, although it may be seen as a win-win situation, this initial configuration was *de facto* making the network less self-sufficient. After all, costs could incur when equipment broke down or if the Wi-Fi spot were no longer available, and there was no plan to monetise the network usage.

At the same time of the CN installation, a very small Internet Service Provider (ISP) – actually a one-man enterprise – was beginning to offer his services in the village. This situation may have determined some competition issues, as the CN could have been considered as an unfair competitor of the abovementioned IPS. To solve this potential conflicting situation, there was an attempt to cooperate with the service provider by using the long-distance link to Resende, provided by the ISP. However, it soon became clear that the CN would not threaten his business due to the very limited capacity for growth of the latter ISP. In this scenario, the CN and the ISP became compatible, working in synergy to provide connectivity to the previously unconnected community.

Besides the workshops and assemblies that took place during the actual installation of the CN, there were three open meetings to specifically address the CN development. The meetings were announced by hanging posters in strategic places that would have benn noticed by the community members. At the same time, an open call for outside volunteers was published. The meeting organisation followed Nuvem's methodology, according to which participants were invited to take part in a collaborative immersion, being responsible for the maintenance of the space, cooking, documenting the whole process, and taking decisions together. A total of 19 people participated, ranging from programmers and academic researchers, to social workers and activists. Two members of Maria Luisa cooperative, from Mulukuku, Guatemala, were also invited by Commotion.

The event was launched on 5 July 2015 with an internal workshop and participant presentations. The next morning, a meeting and workshop for the neighbours was scheduled, with the intention of designing the network. Turnout was low, however, and the activity was postponed to the afternoon, with about 10-to-20 people in attendance. Interesting conversations emerged about the community's common goods, such as the non-working payphone. Part of the attendants volunteered to visit each of the houses in the community and invite more neighbours for a meeting the next day – an approach that proved very successful.

In this context, the first locations for the CN nodes were defined and the link to the public hotspot was established. At first, the link to the public hotspot was established through Wi-Fi, but when the hotspot's router was found, a connection was established via Ethernet cable. Every day, the group of volunteers would move from the farm, where they were hosted, to spend the day in the village, except Wednesday, which was dedicated to internal workshops and equipment configuration. In total, eight nodes were installed. Over the last day, 12 July, the neighbours proposed a few uses for the network, which would have been important for the community, such as creating an application to control the milk production delivered by each producer to the community milk tank.

In retrospect, the bar-raising immersion method was a remarkable success. The open meeting fostered trust within the community, and the joint activities mixing villagers and volunteers was empowering for all community members. The technology also proved to be very stable; the only routers to fail were the ones that were left unprotected from rain for a few months, which were affected by moisture.

Unfortunately, by the end of 2016, the city government stopped paying for the Internet access link – for reasons never clarified – and the company providing the service shut it down. New meetings were called to organise a solution for the long-distance connection. Finally, one of the community members, the owner of a pet shop in Resende, proposed to share her connection. Since the shop had a clear view to the mountains around Fumaça, it was possible to create a 22-kilometer link from there to the Nebulosa farm, which then extended down to the village. This, actually, was a proof of resilience of the network. Until this day, there is no access control in the network; all nodes are setup without a password. New nodes were added with investments made by the community members. Since the pet shop owner never charged for the use of her connection, the network continues to be free-of-charge, enabling unrestricted access to knowledge and communication for the entire local community.

9.3 The Maré experience

Since the Fumaça experience, in 2015, there have been efforts to create a CN in the Maré slum in Rio de Janeiro. The collaboration with community members and local institutions in the Maré slum began right after the Fumaça CN was established, when a few of the participants went to Rio de Janeiro to host a workshop on mesh networks. This latter event was hosted by Galpão Bela Maré, an arts centre maintained by Observatório de Favelas[299] – a nongovernmental organisation (NGO) dedicated to arts and community development, located on the edge of Maré. It lasted from 4:00 PM to 7:00PM for three days, and about 12 people attended, mixing local participants with people who came from different neighbourhoods. The workshop was funded by Olabi,[300] a hackler-lab based in Rio de Janeiro, which is partially funded by a Ford Foundation grant.

Although there were positive results regarding gathering people interested in mesh networks and CN in general, the initiative did not generate enough critical mass to create a new CN. When analysing the experience, the organisers identified a few the issues that contributed to this outcome. First, the location for the network nodes was not ideal. Indeed, the nodes were installed too far from the partnering NGO, thus making it more difficult to maintain the network. Moreover, there were almost no residencies around the NGO's venue, which was surrounded primarily by factories and commercial buildings. Therefore, very few people who were interested in using the network could connect to the infrastructure.

Another problem was the connection to the Internet backhaul. Although the NGO kindly offered to provide the link during the

299 *See* http://www.observatoriodefavelas.org.br/.

300 See https://www.olabi.org.br/.

workshop, it was later found that the connection provided had several technical problems. Notably, the connection speed fluctuated too much, and it could go offline for days. Sharing this already insufficient resource proved impossible, as the NGO staff would ask for the network to be disconnected when they needed to work.

Finally, the timeframe was not enough to create a stable group of users and maintainers. The group that formed around the workshop included few people that lived in Maré, and none of them lived close to the installation. Therefore, the two installed nodes – one on the roof of the NGO building, the other one inside the building – continued to interoperate but were disconnected from the Internet or even to local services.

In 2017, a new attempt was made. A project was submitted to a call published in 2016 by the Culture Agency of the Rio de Janeiro state, in cooperation with Na Favela,[301] a collective created by young filmmakers who live in Maré. The bid was successful, and in May 2017, an open call was published for a weeklong immersion in Na Favela's co-working space, in the middle of the Vila Pinheiro neighbourhood, inside the Maré area.

The call invited people who lived in low-income areas of Rio to take part in a weeklong workshop where they would learn about CNs and help to build one of them. Selected participants would receive a grant including sponsored meals and a financial support part to afford the transportation expenses. Five of the 15 available grants were reserved for inhabitant of the Maré area and 50 people applied. The main criteria used for the selection were the proven involvement in the local community and local politics, especially when it came to organising local spaces, events, and collectives.

Aware of the previous experience, a stable link to the Internet was arranged in advance, in partnership with the Federal University of Rio de Janeiro (UFRJ), with the help of Professor Aline Couri from UFRJ's Fine Arts School (EBA). Since the EBA building is located 1.5 km away from the Na Favela space, the establishment of the link did not only provide access to the global network, but it was

301 See https://www.facebook.com/nafavelaoficial/.

also a useful case study to teach participants how to establish a long-distance connection. The other nodes of the network were planned to be built on the street where Na Favela is based, creating a mesh network. The workshop lasted from 10:00 a.m. to 4:00 p.m. between 3-7 July 2017.

Much was achieved during the workshops, although there was no time to cover much of what was planned, such as the development of local applications, and even a more in-depth discussion about security and privacy online. The first day was dedicated to basic network training, spanning from how to organise CNs to how to construct Ethernet cables. As in Fumaça experience, the LibreMesh firmware was used, so the students learned how to flash routers with this software.

Two nodes were installed on Tuesday 4 July and Wednesday 5 July, including the one that would be connected to the EBA building from the rooftop of the Na Favela office. The workshop held on Thursday, July 6, was taught in the EBA venue and the link was finally established on Friday morning. Overall, the greatest achievement was to form a local group that felt empowered and capable of installing their own network: the last nodes were installed solely by the students.

One difficulty that arose was the fact that, even though Maré has a very densely populated area, people who knew each other do not live particularly close to each other's. Thus, the CN nodes were separated by at least 200 meters from each other. In rural areas, this distance is not very problematic since the electromagnetic spectrum is not particularly polluted and links can be easily established up to 500 meters, sometimes more. But in Maré, the sheer amount of routers, mobile phones, and other devices used by thousands of people made any link above 100 meters almost impossible or of very poor quality. In this context, it was clear that a different strategy will have to be used, either by using long-distance professional equipment suited for LibreMesh or adapting do-it-yourself (DIY) antennas to the routers.

However, the most peculiar issues arose when deciding how to define the access policy for users. Various unusual suggestions were made by community members, spanning from leaving the access point with no passwords to making the SSID (network name) invisible. Such suggestions were mostly due to the fact that Maré is a territory where the Brazilian state has only partial access and control and where rules followed by the local communities are frequently not defined by the state. Police, for instance, will not cross the well-defined boundaries of the slum, which is held by drug traffickers, sometimes from distinct and competing gangs. Importantly, in such environment the activities of the local gangs are not limited to the distribution of illicit substances, but often touch upon almost every aspect of daily life, including the distribution of gas bottles for cooking purposes, the organization of "public" transportation, "security" of local businesses, and also provision of Internet access.

Therefore, the local ISPs could see the open CN as a threat to their business, which in turn could become a threat for the network organisers. There is not a clear solution to this problem, which is probably the most challenging. So far, the nodes that have been established in public spaces, such as Na Favela's offices have passwords, and the nodes in members' houses are using hidden SSIDs. To mitigate risks, it was also decided that this would not be a broad access resource, but one that will reach mainly the collectives and NGOs working within the favela (and some of their workers).

9.4 Conclusions

Based on the experiences described in the previous sections, it can be argued that the lack of good quality connections to the Internet represents a considerable impulse for the development of CNs. In this sense, even though the Maré territory is covered by 3G networks and has a local ISP, the very low quality of the services, the excessive cost (and the limited data caps on mobile networks) make the local craving for alternatives.

The technical difficulties to create a mesh network in a slum are remarkable, but can be overcome by choosing the right technology solutions. In general, the particular characteristics of the favela made it a more challenging project. Moreover, it can be argued that, although CNs have the potential to stimulate the development of local services, such as instant messaging, VoIP, file sharing, *etc.*, the possibility to access existing services was the most appealing argument to initially mobilise the community.

Using the water system as an analogy, it was easy to demonstrate that if Internet connectivity was already available at a neighbour's residence, all one had to do was to lay down the "plumbing" from the neighbour house to the other community members' houses. Since DIY practices are the norm to create infrastructure – spanning from water to electricity to transportation – both in rural areas and in favelas, it is not unthinkable to believe that this culture can be extended to data networking as well.

10 Beyond the Invisible Hand: the Need to Foster an Ecosystem Allowing for Community Networks in Brazil

Nathalia Foditsch

Abstract

The debate over Community Networks (CNs) is not new in Brazil but it needs to gain momentum again. Promoting a good ecosystem is a challenge that goes beyond the technical aspects of deploying and managing such networks. Recent advancements show signs of an increasingly favourable environment for CNs, but a lot remains to be done. This article briefly discusses some challenges and new regulatory developments in Brazil, and how the work of the IGF Dynamic Coalition on Community Connectivity might contribute to the promotion of an ecosystem that favours the establishment of CNs in countries such as Brazil.

10.1 Introduction: Community Networks, Brazil and Rural Areas

This article was written from a rural area of Cunha, a city in the State of São Paulo, Brazil. Cunha is becoming a popular tourist destination, attracting Brazilians and foreigners. It is, in fact, one of the largest municipalities in the State of São Paulo. It offers the charm of artisans in the city and a beautiful landscape in its rural areas. The author of this paper knows Cunha since several decades and has witnessed its development. At first, electricity was not present in some rural areas of the Cunha municipality until the early 90's. Fixed and mobile phones do not reach many of the areas yet, not to mention the very scares availability of Internet connectivity. Some of the individuals living in the rural areas in Cunha, however, have access to wireless Internet but must pay between R$ 130.00 to R$ 200.00 (around USD40 to USD60) for 2MB per month.[302] This means that some of the locals have to pay about 20% of their (minimum) wage to have Internet access. Such percentage is much higher than the target set by

302 In Brazil, while fixed broadband is charged per speed, data caps in mobile Internet are widespread.

the Alliance for Affordable Internet (A4AI), a total price of 2% or less of the GNI per capita.[303] In this perspective, it must be noted that, while many countries have broadband access policies in place, few have been able to solve the issue of access in areas of less interest to commercial telecommunication providers, and Brazil is not an exception.

The reality described above would have been different had the citizens of rural areas in Cunha had access to connectivity provided through Community Networks (CNs), which "rely on the active participation of local communities in the design, development, deployment, and management of shared infrastructure as a common resource, owned by the community, and operated in a democratic fashion", according to the definition of the Declaration on Community Connectivity.[304] While the creation of CNs is a viable option for providing Internet connectivity, the impact of such networks goes beyond mere access, as they also aim at promoting community participation and citizen empowerment. However, as highlighted by Byrum (2015) such goals are not immediately fulfilled upon the establishment of a CN, but they have the potential of "disciplining the broadband market, expanding access to underserved areas, fostering innovation communities, and demonstrating alternative service models and types of partnerships" (Byrum 2015).

Navarro *et al.* (2016), developed a comprehensive report on "Existing Community Networks and their Organisation", in which they describe the different CNs, which use different infrastructures and have various governance arrangements. They explain that, while many initiatives might be described as CNs, many are in fact top-down ISPs or municipal networks. As such, the authors highlight that:

> "Many initiatives are sometimes defined as Community Networks, but only when looking at their organisation, governance and business model we can classify them

303 See http://a4ai.org/1for2-affordability-target/

304 See DC3 (2017).

> as crowdsourced networks (a loose and informal interconnection of routers without a socio-economic organisation), as community networks, as top-down ISPs (such as Wireless ISP or WISP, for profit or not), as municipal networks (run or managed by a municipality or other governmental organisation), among several other models." (Navarro *et al.* 2016)

Thus, not all communities that proclaim to have established a CN have *de facto* established one, for CN are understood to be the ones that operate under the principles of non-discrimination, open access and open participation (Navarro *et al.* 2016).

CNs can make use of different wired and wireless infrastructures and wireless technology Wi-Fi - IEEE 802.11 has become popular among CNs due to its low cost and ease of deployment (Meinrath *et al*. 2013; Frangoudis *et al*. 2011). Wireless Community Networks (WCNs) are thus more common than wired community networks. WCNs are also commonly structured via a "mesh network" architecture. Mesh networks are "decentralised network infrastructures that rely on a distributed and loosely coordinated network of peers contributing their own resources to the network so as to provide Internet connectivity to a specific community without relying on any pre-existing network infrastructure." (De Filippi 2015).. These networks are very resilient to network failure and "grow organically with minimal coordination which give them maximum resiliency: with mesh topology, there is theoretically no single points of failure to jeopardize the functioning of the local network" (De Filippi and Tréguer 2015:4) They dynamically adapt over time, as nodes continue to operate, even when some of them are not able to communicate (Frangoudis *et al.* 2011).

In the same rural area described above, in the city of Cunha, the family of this author went through a major disaster, in 2010. Six family members died due to a landslide. Amid the tragedy, major disaster relief errors have happened. For example, a helicopter from a major broadcasting company landed on the only available spot near the accident, preventing public security to land on the same place. Moreover, the only public telephone in the village near the accident was monopolised by journalists trying to cover the disaster, and there was no cell phone signal in the area. The constrains in communication made it very hard, notably for the relatives, to have information about the accident. Having mesh networks in place would have immensely helped the disaster relief and would have facilitated effective coordination, preventing the "overreliance on a single form of technology that may be disrupted during a crisis". (Picard and Pickard 2017:13). Unfortunately, there was no emergency communications strategy at the time and the lack of communications led to a disastrous failure.

Unfortunately, among the possible underlying reasons why no CN has ever been put in place in that rural area of Cunha, is the fact that the local community is not even aware this is a possibility,[305] and see existing commercial options as the only possible solution for connectivity. Moreover, these communities might lack the appropriate technical expertise. Further, there are capital expenditures (CAPEX) and operational expenditures (OPEX) involved in establishing and maintaining such networks. Navarro *et al.* (2016) have also shown that one of the challenges of establishing a wireless CN in a rural area is that it has a higher CAPEX in compared to non-rural or semi-rural areas. In fact, in one of the cases considered by the authors in Catalonia, it was found that the CAPEX in a rural area was the double amount of the CAPEX in a semi-rural area.

10.2 The Current Status of Policy and Regulation in Brazil

The development of WCNs is closely related to the spectrum management of each country, as communities frequently rely on unlicensed spectrum to operate CNs. In Brazil, a legal framework allowing for the use of "equipment for restricted radiation" has existed since 2008.[306]

305 Based on the conversation I had with some local leaders.

306 Anatel Resolution #506/2008, which was revoked by Anatel Resolution #680/2017

Box: Can WCNs operate without Anatel's authorisation?

There used to be a controversy related to whether regulation can be interpreted in a sense that CNs do not need an authorisation from Anatel – *i.e.* the Brazilian telecoms regulator – in order to start its activities.[307] However, Anatel Resolution #680, published on June 27th 2017, has established that regardless of its commercial or non-commercial status, with or without profit (i) communities and operators with less than 5000 access points do not need a license or authorisation in order to operate equipment that uses "restricted radiation"; (ii) and communities are dispensed from acquiring an authorisation in order to provide services as a Multimedia Communication Service (SCM) or Limited Private Service (SLP) when they are willing to use equipment of restricted radiation or confined media. Notwithstanding, amongst the entities dispensed from such license/authorisation, must communicate to Anatel their intention of initiating SCM or SLP activities, before starting them.[308] Prior to the enactment of Resolution #680/2017, there was a cost involved in acquiring such authorisation (around USD 150.00), according to what had been previously established by Anatel, in 2013.[309] Such changes in regulation show a positive effort to foster a better regulatory environment for CNs. Lastly, it should be pointed out that, regardless of what the legal interpretation is, using equipment that has been approved by Anatel is always mandatory, following the Brazilian General Telecommunications Law.[310]

In Brazil, there are over five thousand small and medium sized ISPs (Perez & Vale 2016).[311] Such figures are a great example to the rest of the world, although a very high percentage of the total

307 See Artigo 19 et al. (2017).

308 Anatel Resolution #680/2017

309 Anatel Resolution #617/2013

310 Law # 9472/97; art. 162, §2º

311 According to Perez and Vale (2016), this high number of operators was the result of unintended regulatory measures established in the early days of the Internet in Brazil.

connections are made through the major telecommunication companies. Nonetheless, there are still areas in the country lacking connectivity, and beyond that, it is important to note that CNs have a much broader purpose, fostering community relations and promoting the creation of local services, as argued above. However, there are currently not many active CNs in Brazil,[312] despite the existence of a legal framework providing some answers to the problems commonly shared by CNs.[313]

The reasons for such lack of widespread adoption of CNs vary. Besides the awareness issue mentioned above, communities might lack appropriate funding for initiating their operations. For example, Nuvem, which is working on supporting some communities, had a grant from a foreign organisation in order to be able to start its first project, with Fumaça Village.[314] Technical aspects might also be a barrier to be considered. It is not hard to imagine that several communities around the country would be interested in initiating a CN but lack the appropriate technical expertise to do so.

Despite the small number of CNs in Brazil, efforts to democratise the access to broadband Internet at the community level have also been undertaken by the Federal Government. One example is the license for municipalities that was created in 2007. For R$400.00 (less than USD 150.00) municipalities can deploy their own networks using unlicensed spectrum, as long as the devices used are the ones certified by Anatel, and municipalities operate networks within their geographic limits. Such possibility was promoted following the advice of the Brazilian Internet Steering Committee (CGI.br) and the National Research Network (RNP) (Afonso &Valente 2010).

Another example of efforts to promote empowerment at the local level is the deployment of the so-called Community Networks of Education and Research (Redecomep). They are "high capacity

312 See e.g. Navarro et al. (2016) assessed Community Networks around the world and found one active community in Brazil, the Rede Mesh Novo Hamburgo. However, it does not seem like they are active anymore. Notwithstanding, the organisation Coolab is fostering some new communities, see: http://www.coolab.org/quem-somos/

313 See Afonso and Valente (2010)

314 See Fumaça Community, which received a grant from Commotion Wireless. http://nuvem.tk/wiki/index.php/Fuma%C3%A7a_Data_Springs

networks deployed by RNP in metropolitan areas served by the points of presences (PoPs) of the RNP backbone, and in some other cities with two or more user institutions. These networks allowed the provision of high capacity access to the (educational institutions) *campi*, typically at 1 or 10 Gbps, using Ethernet technology, usually in a ring configuration, to provide redundancy" (Stanton & Grizendi 2016:19). Redecomeps are managed by the National Research and Education Network (RNP), and currently count with 26 networks, and their operation, maintenance and upgrade is under the responsibility of the local administrators (Stanton & Grizendi 2016).

While these last two policy and regulatory advancements are not linked and limited to CNs in the strict sense, they show that there is demand for strategies that allow for the management of networks at the local level. Despite such efforts, the Brazilian legal framework needs improvements in order to allow new technologies to be tested and adopted.

A good example is that spectrum management does not allow yet for the use of technologies that take advantage of the unlicensed parts of the spectrum, such as the TV White Spaces (TVWS). Indeed, although promoting changes in regulation to allow for the exploitation of TV White Spaces is something that has been discussed since 2010, the general use of TVWS technologies is not a possibility in Brazil yet (Foditsch & Belli 2016) and Anatel is waiting for the completion of the analogue switch-off in order to start debating TVWS.[315]

Communities and individuals would also benefit from having a regulatory framework that allows for a wide experimentation and use wireless new technologies, even if such technologies may not necessarily be utilised by CNs. Allowing for various uses of unlicensed spectrum would particularly benefit new entrants and promote new governance models, and consequently positively affect the experimentation of CNs. In this perspective, Meinrath (2005) stresses that abuses from the industry have historically prevented many initiatives with a public interest to take off and promoting innovating unlicensed spectrum uses is a way to correct for such abuses.

315 See Aquino (2017).

10.3 Conclusions

In Brazil, the debate over CNs and their role for communities has existed for several years and a regulatory framework covering many issues interesting CNs is in place. Recent regulatory advancements show an effort to strengthen such regulatory environment, but a lot remains to be done in terms of promoting an ecosystem that is favourable to CNs. Brazil is, thus, a good example of a country that might greatly benefit from initiatives such as those promoted by Internet Governance Forum Dynamic Coalition on Community Connectivity (DC3).

The challenges in promoting a good ecosystem surpass the technical aspects of deploying and managing CNs. As argued by Navarro *et al*. (2016), since technology has commoditised, the main challenges go beyond the technological aspects and relate to how such communities emerge, how they are organised, who and how is able to participate; and how they become and maintain themselves becoming sustainable and adaptable. The DC3 can certainly help filling this gap, contributing to the Brazilian reality in different ways, such as prmoting an assessment of the main bottlenecks and reasons why there are not many CNs around the country; increasing the awareness of the role that can be played by CNs in serving as a viable option for connectivity; and showcasing their benefits, which transcend the connectivity itself.

With regard to spectrum management specifically, DC3 might have a positive impact helping raising awareness about the need for the use of unlicensed spectrum and promoting good practices and regulatory changes to promote such use. Although Noam (1998:788) has mentioned that "time will surely come and fully bring the invisible hand to the invisible resource", we should not solely rely on such invisible hand. Rural areas such as the ones in the city of Cunha would have the option of having a more resilient network, and ultimately be more prepared to deal with incidents such as the one described above. Such changes do not happen from night to day, neither without a concerted effort.

10.4 References

Aquino, M. O refarming da faixa de 1,8 ghz deve estar concluído em 2020 no Brasil. *Tele.síntese*, abr. 2017. http://www.telesintese.com.br/anatel-conta-com-fim-da-2g-na-faixa-de-18-ghz-em-2020/.

Artigo 19; Instituto Bem-Estar Brasil; ANID - Associação Nacional para Inclusão Digital. 2017. Como Montar e Regularizar um Provedor Comunitário". http://artigo19.org/wp-content/blogs.dir/24/files/2017/01/Como-Montar-e-Regularizar-um-Provedor-Comunit%C3%A1rio1.pdf

Byrum, Greta. 2015. *What are Community Wireless Networks For?* The Journal of Community Informatics. http://ci-journal.net/index.php/ciej/article/view/1227/1167

DC3 (2017). "Working Definitions and principles". 2017. Available at https://www.comconnectivity.org/article/dc3-working-definitions-and-principles/

De Filippi, Primavera. *Community Mesh Networks: Citizens Participation in the Deployment of Smart Cities.* Vesco, A. & Ferrero, F. Social, Economic, and Environmental Sustainability in the Development of Smart Cities, IGI Global, pp. 298–314, 2015, Social, Economic, and Environmental Sustainability in the Development of Smart Cities.

De Filippi, Primavera; Felix Treguer. 2015. *Expanding the Internet Commons: The Subversive Potential of Wireless Community Networks.* Journal of Peer Production, 2015.

Foditsch, Nathlia and Luca Belli. 2016. *Da escassez à abundância: sobre o debate acerca do uso eficiente do espectro eletromagnético*. In Banda Larga no Brasil: Passado, Presente e Futuro. Knight, Feferman and Foditsch (Orgs.) Published by: Editora Novo Século.

Frangoudis, Pantelis A., George C. Polyzos, and Vasileios P. Kemerlis. *Wireless community networks: an alternative approach for nomadic broadband network access.* IEEE Communications Magazine 49, no. 5 (2011): 206–213.

Meinrath, Sascha. 2005. *Wirelessing the world: The battle over (community) wireless networks*. 2005. In The future of the media: Resistance and reform in the 21st century. Pages 219-242. Seven Stories Press.

Meinrath, Sascha D., James Losey, e Benjamin Lennett. 2013. *Afterword. Internet Freedom, Nuanced Digital Divide, and the Internet Craftsman*. In , 309–16. Routledge. Available at http://su.diva-portal.org/smash/record.jsf?pid=diva2%3A693036&dswid=-9394

Navarro, Leandro, Felix Freitag, Félix Tréguer, Leonardo Maccari; Panagiota Micholia, Panayotis Antoniadis. 2016. *Report on Existing Community Networks and their Organisation*. Network Infrastructure as Commons. Co-Funded by the Horizon 2020 programme of the European Union. Grant Number 688768

Noam, Eli. 1998. *Spectrum Auctions: Yesterday's Heresy, Today's Orthodoxy, Tomorrow's Anachronism. Taking the Next Step to Open Spectrum Access*. The Journal of Law & Economics , Vol. 41, No. S2 (October 1998), pp. 765-790 Published by: The University of Chicago Press for The Booth School of Business, University of Chicago and The University of Chicago Law School Stable URL: http://www.jstor.org/stable/10.1086/467412

Perez, Basílio, Breno Vale. 2016. *A Contribuição das Pequenas e Médias Operadoras*. In Banda Larga no Brasil: Passado, Presente e Futuro. Knight, Feferman and Foditsch (Orgs.) Published by: Editora Novo Século.

Picard, Robert, Pickard, Victor. 2017. *Essential Principles for Contemporary Media and Communications Policymaking*. Reuters Institute for the Study of Journalism.

Stanton; Michael, Eduardo Grizendi. 2016. *A Rede da RNP e Novas Parcerias.* In Banda Larga no Brasil: Passado, Presente e Futuro. Knight, Feferman and Foditsch (Orgs.) Published by: Editora

11 Diseño e Implementación de una Aplicación Web para la Visualización Mundial de Despliegues de Redes Comunitarias

Maureen Hernandez

Abstract

At present, there are several community networks deployed and organisations involved around the world but it is hard to obtain a summarisation or characterisation of the deployments of such networks. No database or repository providing basic information about community networks, such as the name, localisation, and contact person, exist. In order to facilitate interactions among stakeholders and take advantage of the lessons learned, instead of letting each Community starting from zero, this paper takes a step foward, proposing a solution to organise these initiatives, highlighting all efforts that have been made to date, which are emerging from initiatives like the UN IGF Dynamic Coalition for Community Connectivity or the research group Global Access to the Internet for All (GAIA), from the Internet Research Task Force (ITRF). Starting from the consideration that a visual record of Community network deployments was absent until now, this paper argues that the ability to visualise the work that has been done by different communities around the world is an important factor not only to promote and inspire more deployments but also to understand how far these initiatives have come and how different their characteristics may be. As such, the proposed "Community Connectivity Map" aims at drawing on the world map all the community networks, which can be registered by stakeholders themselves and validated manually. The data collected by the Community Connectivity Map would be managed as the community decides and will not be used in any case outside the agreement among the stakeholders.[316]

316 The English version of this article will be published by the author at https://mauhernandez.github.io/dc3-2017-community-networks-location.pdf

11.1 Introducción

El presente proyecto se estructura de la siguiente manera: 1. Introducción: donde se presentan los antecedentes, el estado del arte, el alcance, objetivo de la aplicación y la metodología de desarrollo. 2 Diseño y arquitectura de la aplicación: Se listan las pantallas, el esquema de base de datos, los componentes, los métodos de representación, pantalla, casos de uso y arquitectura de sistema. 3. Conclusiones y Recomendaciones. Finalmente se presentan las referencias bibliográficas.

Desde hace algunos años las redes comunitarias vienen emergiendo alrededor del mundo, estos esfuerzos por empoderar comunidades han sido loables debido a sus resultados, sin embargo, han tenido que realizar esfuerzos prácticamente desde cero al no aprovechar mejores prácticas o soluciones de iniciativas anteriores, probablemente debido al esparcimiento de los esfuerzos.

Gracias a iniciativas como la Coalición Dinámica de Conectividad (DC3)[317] y el grupo de investigación global para Internet para todos (GAIA)[318] se ha logrado juntar esfuerzos y concentrar gran parte de las iniciativas globales, sin embargo, los esfuerzos y marcos de trabajo varían crucialmente de una región a otra ya que gran parte de las variables como asequibilidad, igualdad, geografía y políticas son distintas

Se observa la necesidad de realizar un survey sobre el estado de las redes comunitarias, los desafíos y las problemáticas que estas iniciativas están afrontando en la región y para las cuales quizás no existen herramientas diseñadas en función de la problemática latinoamericana; existen visiones generales que plantean los pasos a tomar para promover conectividad pero aplicar estas métricas a nuestra región es un trabajo difícil que requiere de una integración de distintos actores, quizás ubicar las soluciones más cercanas al lugar donde se desea realizar el proyecto es una opción que provea de mejores oportunidades de éxito.

Es por esto que motivada por la problemática de no contar con un sistema que liste los despliegues o provea una caracterización

317 Dynamic Coalition Community Connectivity – See https://comconnectivity.org/.

318 Global Access Internet For All – See https://datatracker.ietf.org/rg/gaia/about/.

geográfica he considerado apropiado crear una aplicación web que permita mapear las redes comunitarias, es decir, representar en un mapamundi su ubicación y características principales con el fin generar la capacidad de conocer un poco más quienes son y donde estas, cuál es su tecnología y como encontrarlos.

11.1.1 Antecedentes

No se encontraron sistemas que realicen un trabajo parecido con las redes comunitarias, especialmente una representación visual, sino varios estudios que listan o agrupan por categoría algunos despliegues por ejemplo "*Supporting the Creation and Scalability of Affordable Access Solutions: Understanding Community Networks in Africa*[319]" o numerosos artículos que hablan sobre sus propios despliegues y experiencias.

11.1.2 Alcance

Este proyecto pretende beneficiar a todos los involucrados o interesados en redes comunitarias en el mundo para darse cuenta que son parte de una red más grande y hacer contacto con las comunidades cercanas o que hacen uso de la misma tecnología para así poder generar fortalezas y retroalimentación, también permite que se manifiesten como una comunidad en sinergia.

11.1.3 Propósito

Dicen que para saber a dónde vamos hay que saber de dónde venimos, poder generar una forma de contacto con otras redes comunitarias es una necesidad actual en el ecosistema, la aplicación vendría siendo una guía visual para esto, permitiendo ser incluso una herramienta para el análisis y en etapas posteriores, sujeto a previa autorización de los usuarios un análisis de los datos suministrados y una forma de caracterizar sus métricas y tiempo de funcionamiento, las posibilidades son infinitas.

11.1.4 Metodología

Se trabajó y trabajaran las etapas futuras con un modelo en espiral. La iteración cero fue el diseño del marco de trabajo para un sistema

319 Supporting the Creation and Scalability of Affordable Access Solutions: Understanding Community Networks in Africa – See https://www.internetsociety.org/doc/cnafrica.

que permita el registro y visualización mundial de despliegues de redes comunitarias. La primera iteración consistió en la creación del sistema mediante una interfaz que permita el registro y la visualización de la data basado en una arquitectura RESTful[320] y MVC[321]. En las recomendaciones y conclusiones se listan posibles iteraciones futuras.

11.1.5 Objetivo

La representación visual de la ubicación de despliegues de redes comunitarias. La aplicación Community Connectivity Map está creada con el fin principal de tener un registro visual de estas iniciativas, pero también considero que su existencia podría incentivar la creación de otras redes de este tipo en el mundo.

Finalmente tiene objetivo de no solo mostrar las redes activas sino todas aquellas que han sido creadas en algún momento, funcionando como un registro histórico de redes comunitarias, esta diferenciación podrá especificarse en una versión posterior.

11.2 Diseño y Arquitectura de la Aplicación

La versión actual de la aplicación es una versión minimalista donde se persigue el mínimo producto viable (MVP, por sus siglas en inglés)[322] para lograr la correcta visualización de cada despliegue mediante la ubicación de sus coordenadas en un mapamundi. Esta primera versión permite solicitar la agregación de una red comunitaria ya que es necesario que sea el usuario común (encargado o involucrado con el despliegue) quien funja como facilitador de los registros que son fundamentales para la visualización.

La primera versión de la aplicación se realizó utilizando Node.js[323] como lenguaje principal del servidor, valiéndonos del framework Express.js[324] y Sequelize[325] para proporcionar una arquitectura del servidor aproximadamente MVC. Se necesitaba usar Express porque

320 RESTful API – See http://searchcloudstorage.techtarget.com/definition/RESTful-API.

321 Modelo MVC – See https://en.wikipedia.org/wiki/Model%E2%80%93view%E2%80%93controller.

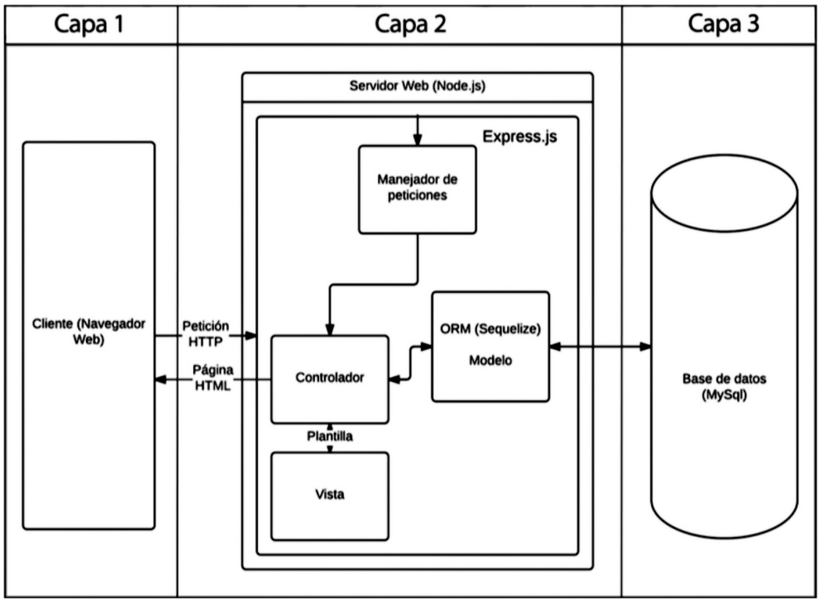
322 Minumun Viable Product. – See https://en.wikipedia.org/wiki/Minimum_viable_product

323 Node.JS – See https://nodejs.org/en/

324 Express Framework – See https://expressjs.com/

325 Sequelize Documentacion – See http://docs.sequelizejs.com/

Node.js por sí solo no cuenta ni con un manejador de base de datos lo cual era necesario en la capa de persistencia ni método de creación para las rutas HTTP[326].



Para diseñar la base de datos es necesario conocer la representación lógica de los datos que pueden ser subidos por los usuarios, la idea es que cada registro en la tabla sea una red comunitaria reportada. En la base de datos se almacenan las coordenadas, el nombre, el sitio web, nombre contacto principal y correo, numero de nodos, cantidad aproximada de usuarios y tecnología física que utiliza.

11.3 Abstracción de la Red Comunitaria

La red comunitaria está ubicada en un lugar específico, este lugar está compuesto por coordenadas geográficas y estas no son más que un conjunto de latitudes y longitudes, no repetidas que es reportada inicialmente por el usuario. La representación se hace mediante un punto cuyo centro esta denotado por dichas coordenadas, además almacenamos los parámetros de interés para el simple análisis de los usuarios. Para acompañar este registro utilizamos una tabla con la información de contacto de quien la registra.

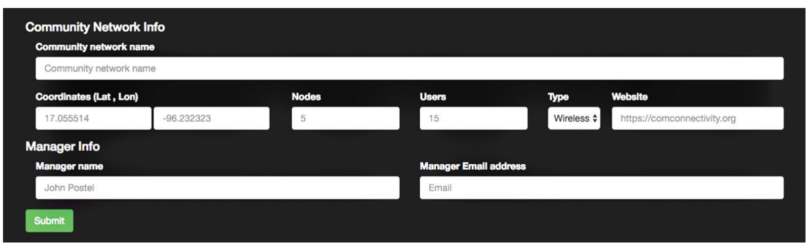
326 HTTP Metodos – See https://developer.mozilla.org/es/docs/Web/HTTP/Methods

Nombre de la entidad	Función
Managers	Almacena nombre y correo electrónico del usuario que registra la red y funge como persona de contacto
Redes comunitarias	Almacena coordenadas, sitio web, numero de nodos, cantidad aproximada de usuarios, tecnología física (espectro, fibra óptica o enlace satelital) que utiliza y booleano de validación.

11.4 Pantallas

Pensando en lograr la mejor experiencia de usuario creamos las siguientes pantallas:

1 Pantalla inicial: Introducción al proyecto, información de contacto, sitios de interés y formulario de registro que permite el registro de la red comunitaria como una instancia.



2 Visualización del mapa interactivo: Construido con el API de Google Maps[327] permite ubicar en el mapa todas las instancias de redes que hayan sido registradas y su información básica.

327 Google Maps API – See https://developers.google.com/maps/

3 Pantalla de administradores: Disponible para administrar las nuevas solicitudes (aceptar o rechazar)

a Aceptación de una red comunitaria: Permite que cambie el booleano de validación logrando de esta forma que la red se dibuje en la nueva actualización del mapa.

i. Rechazo de una red comunitaria: No elimina la red, pero mantiene el booleano de validación falso.

Community Networks Map Resources Register your network

Network List

#	Name	Latitude	Longitude	Website	Nodes	Users	Technology
10	Tunapandanet	36.780923	-1.312628	http://www.tunapanda.org/	20	150	Wireless
4	B4RN	-2.6140518	54.137946	https://b4rn.org.uk	3270	9000	Fiber
1	Altermundi	-64.4276374	-31.8075906	http://altermundi.net/	10	150	Wireless
9	Akwapim Community Wireless Network	-1.0920878	5.9666668	https://dokumen.tips/documents/akwapim-ghana-community-wireless-network-brief-background-ghana-located.html	20	20	Other
6	BUKAVU	28.8540029	-2.5118016	bukavu.mesh	0	0	Wireless
2	Rhizomatica	-96.2475031	17.3618408	https://www.rhizomatica.org/	12	200	Other
12	Fantsuam Foundation	7.3592602	10.5070688	http://www.fantsuam.org/	1	100	Wireless
3	Guifi.net	0.0397531	40.037992	https://guifi.net	1000	40000	Fiber
13	ICT4RED	27.5471284	-32.0195607	https://ict4red.co.za/	12	100	Other

La información recibida por parte de los usuarios será compartida con la comunidad si estos lo permiten y bajo ningún concepto corresponderá o será utilizada para un fin comercial o de cualquier tipo distinto a lo especificado en este documento.

11.5 Componentes

A continuación, se muestran algunas especificaciones abstractas de los componentes desarrollados por el sistema y que funciones llevan a cabo:

1 Registrador de redes:

Generado mediante Formulario HTML[328] y solicitudes al servidor permite crear un registro en la base de datos con las características que hemos mencionado anteriormente, es quien permite la persistencia de los datos

328 Especificacion HTML – See https://en.wikipedia.org/wiki/HTML

2 Manejo de solicitudes de registro:

   a Activar la visualización una red: Esta función permite que la bandera de validación sea verdadera, esto es todo lo que se necesita para que la red sea incluida en la visualización del mapa.

   b Desactivar de una red: El booleano de validación permanece negativo por lo que la red no se incluye en el mapa, los datos se mantienen para facilitar una posterior validación o reactivación, es el estado de las redes por defecto.

Además de esto se creó un API endpoint encargado de proveer los marcadores a insertar en el mapa y dos enrutadores principales, uno para el workflow del usuario (inicio, registro y mapa) y uno para el del administrador (Inicio / Login, administrador de redes)

11.6 Casos de Uso

- Administrador: El administrador es quien decide si validar o no una red, para esto hace una comprobación manual de los datos suministrados por el usuario y en la pantalla de administración realiza las acciones sobre las solicitudes listadas.
- Usuario: En la primera versión de la aplicación los usuarios no están autenticados, por lo que sus casos de usos son simples, un usuario puede registrar una red o visualizar el mapa y explorar la información básica de las redes presentes en el mapa para el momento de la consulta.

11.7 Conclusiones y Recomendaciones

Esta aplicación en un principio es una manera real de evidenciar todos los despliegues presentes en el planeta que puedan ser considerados como una red comunitaria lo cual desde una perspectiva neutral podría incentivar más despliegues de este tipo, además de permitir a otras redes comunitarias la posibilidad de entrar en contacto.

Las iteraciones siguientes futuras son: crear sistema de cache en el cliente, permitir filtrado de redes (dependiendo de su estado, tipo, ubicación, entre otras), migrar a una aplicación web progresiva y crear API[329] endpoints para permitir a las redes sumarizar estadísticas de conectividad.

La intención de migrar a aplicación web progresiva[330], se debe a que cuando se inicia desde la pantalla de inicio del usuario en un dispositivo móvil, los trabajadores de servicio que se utilizan en aplicaciones web progresivas permiten que una aplicación se cargue instantáneamente, independientemente del estado de la red, un trabajador de servicio, escrito en JavaScript, el cual es el lenguaje nativo de la aplicación funciona un proxy del lado del cliente y te pone en control de la caché y cómo responder a las solicitudes de recursos, esto puede eliminar la dependencia de la red, asegurando una experiencia instantánea y confiable para sus usuarios, lo cual es sumamente relevante para poder garantizar el funcionamiento en las comunidades remotas con conectividad limitada que son el alma de este movimiento.

Para democratisar el acceso, combatir la desigualdad y promover los beneficios sociales y económicos que vienen de la mano del acceso a Internet se necesita evaluar estratégicamente distintos puntos de vista y así promover su supervivencia y evolución. Generalmente la documentación (cuando existe) se basa en un aspecto técnico y abstracto limitado a la construcción de enlaces y configuración de antenas o routers y no se poseía hasta este momento una herramienta que permitiera la fácil ubicación de las mismas.

Se espera que esta herramienta provea una solución al paso previo al análisis del estado de redes comunitarias mediante la correcta ubicación de todas las redes existentes, minimizando entonces el esfuerzo de tener que listar y caracterizar desde cero los despliegues existentes. Se pretende mediante un desarrollo en espiral poder incrementar los usos de la misma para satisfacer necesidades de la comunidad en caso de que la misma las manifieste.

329 API Definition – Online: http://www.webopedia.com/TERM/A/API.html

330 Aplicacion Web Progresiva segun Google – Online: https://developers.google.com/web/progressive-web-apps/

11.8 Referencias

API Definition http://www.webopedia.com/TERM/A/API.html

Aplicacion Web Progresiva segun Google. https://developers.google.com/web/progressive-web-apps/.

Dynamic Coalition Community Connectivity. https://comconnectivity.org/

Especificacion HTML. https://en.wikipedia.org/wiki/HTML

Express Framework.https://expressjs.com/

Global Access Internet For All. https://datatracker.ietf.org/rg/gaia/about/

Google Maps API. https://developers.google.com/maps/

HTTP Metodos https://developer.mozilla.org/es/docs/Web/HTTP/Methods

Minumun Viable Product. https://en.wikipedia.org/wiki/Minimum_viable_product

Modelo MVC – Online https://en.wikipedia.org/wiki/Model%E2%80%93view%E2%80%93controller

Node.JS. https://nodejs.org/en/

RESTful API. http://searchcloudstorage.techtarget.com/definition/RESTful-API

Sequelize Documentacion – Online. http://docs.sequelizejs.com/

Supporting the Creation and Scalability of Affordable Access Solutions: Understanding Community Networks in Africa. https://www.internetsociety.org/doc/cnafrica

12 Declaration on Community Connectivity

This Declaration was elaborated through a multistakeholder process, between July 2016 and March 2017. This participatory process was initiated and facilitated by the UN IGF Dynamic Coalition on Community Connectivity (DC3). Initial inputs and comments to this document have been provided through an online consultation, open to both DC3 members and non-members via the mailing list of the DC3, between July and November 2016.[331] Subsequently, an ample range of stakeholders gathered during the 2016 IGF meeting, in Guadalajara, to provide feedback and further discuss the text resulting from the consultation. Feedback provided on site and via the IGF website were consolidated into a further version of the Declaration that was subsequently shared on the DC3 mailing list – which is open to the participation of all interested individuals – for a further open consultation, between December 2016 and March 2017. The final comments were consolidated into this version, to which no DC3 member, nor any other subscriber to the DC3 mailing list has manifested opposition.[332] It should be noted that the Declaration is a living document and, as such, it may be updated by future versions, should this be the common view, emerging from the discussions facilitated by the DC3.

12.1 Preamble

Over four billion people may remain unconnected to the Internet, including approximately one billion who do not have access to basic telephony services. Most people in rural and economically disadvantaged areas are unlikely to realise the benefits of connectivity in the near term. Rural communities and slum dwellers represent almost 60% of the worldwide population and, to date, traditional Internet access models have failed to provide coverage to such populations.

331 The version of the Declaration that was debated at the IGF 2016 can be accessed at http://www.intgovforum.org/multilingual/index.php?q=filedepot_download/4189/174.

332 See the DC3 open archives http://listas.altermundi.net/pipermail/dc3/ as well as http://www.intgovforum.org/multilingual/content/2016-dynamic-coalition-output-documents.

To reverse these trends, it is necessary to create appropriate frameworks that allow communities and local entrepreneurs to solve their own connectivity challenges. Bottom-up strategies that embrace non-discriminatory treatment of data traffic and diversity in the first mile can empower individuals and communities, allowing them to play an active role as co-creators of local Internet and communication infrastructure. We acknowledge that communication technology does not have a neutral impact and can exacerbate unequal power relations in the community, and so community networks should strive to implement more inclusive and just alternatives.

12.2 Connectivity

Connectivity is the ability to reach all endpoints connected to the Internet without any form of restriction on the data-packets exchanged, enabling end-users to run any application, access and share any type of content and service via any device as long as this does not harm the rights of others. Connectivity is the goal of the Internet.

12.3 Community Networks

We embrace the potential of community networks as a vehicle for transformation that increases the agency of all community members, including by fostering gender-balance. Community networks are structured to be open, free, and to respect network neutrality. Such networks rely on the active participation of local communities in the design, development, deployment, and management of shared infrastructure as a common resource, owned by the community, and operated in a democratic fashion. Community networks can be operationalised, wholly or partly, through individuals and local stakeholders, NGO's, private sector entities, and/or public administrations. Community networks are recognised by:

a Collective ownership: the network infrastructure is managed as a common resource by the community where it is deployed;

b Social management: the network infrastructure is technically operated by the community;

c Open design: the network implementation and management details are public and accessible to everyone;

d Open participation: anyone is allowed to extend the network, as long as they abide by the principles and design of the network;

e Promotion of peering and transit: community networks should, whenever possible, be open to settlement-free peering agreements;

f Promotion of the consideration of security and privacy concerns while designing and operating the network;

g Promotion of the development and circulation of local content in local languages, thus stimulating community interactions community development.

12.4 Community Network Participants

Community network members are considered active participants, and should be considered both producers and users of content, applications, and services. Notably, community network participants must:

a Have the freedom to use the network for any purpose as long as they do not harm the operation of the network itself, overburden the network, the rights of other participants, or the principles of neutrality that allow content and services to flow without deliberate interference;

b Have the right to know the technical details and operation of the network and its components, and to share knowledge of its mechanisms and principles;

c Have the right to offer services and contents to the network, while establishing their own terms;

d Have the right to join the network, and the obligation to extend this set of rights to anyone according to these same terms.

e Promote full gender balance

12.5 Policy Affecting Connectivity and Community Networks

National as well as international policy should facilitate the development of community connectivity and the deployment of community networks. National and international policy should:

a Take into account individuals' human rights to freedom of expression and privacy;

b Lower barriers that may hinder individuals' and communities' capability to create connectivity, including gender barriers;

c Allow the commons-based use of existing unlicensed spectrum bands or unused licensed spectrum for public-interest purposes, and consider the growth in use of unlicensed spectrum bands and the establishment of special licenses which address the needs of community connectivity;

d Incentivise the development and adoption of technologies based on open standards, free software and open hardware to improve the replicability and resilience of community networks;

e Allow for the deployment of technologies based on dynamic access of spectrum and other new technologies that do not necessarily have a full regulatory framework in place supporting them;

f Promote the elaboration of appropriate frameworks and the utilisation of existing funds, such as universal service funds or other specific telecommunication development funds, towards advancing community connectivity.

13 Main Acronyms and Abbreviations

3G Third-generation wireless mobile telecommunications

4G Fourth-generation wireless mobile telecommunications

AAI Airports Authority of India

AGR Adjusted gross revenue

ANATEL National Telecommunications Agency of Brazil

BDMA Beam Division Multiple Access

BSL Basic service licenses

BSNL Bharat Sanchar Nigam Limited

BTS Base transceiver station

BWA Broadband wireless access

C-ISP Community-based Internet service providers

CDMA Code Division Multiple Access

CIRC Community information resource centre

CMTSL Cellular Mobile Telephone Service License

CN Community network

CPR Common-pool resources

CWIRP Community Wireless Infrastructure Research Project

dBm Decibels relative to one milliwatt

DEF Digital Empowerment Foundation

DFS Dynamic frequency selection

DoT Department of Telecommunications

DSL Digital subscriber line

DTH Direct to home

E-commerce Electronic commerce

EC European Commission

EGoM Empowered Group of Ministers

EFP Effective radiated power

EU European Union

EV-DV Evolution-Data and Voice

FBG Financial bank guarantee

FCC Federal Communications Commission

FM Frequency modulation

FMC Fixed-mobile convergence

Gbps Gigabits per second

GHz Gigahertz

GSM Global System for Mobile Communication

HSDPA High-speed Downlink Packet Access

HSUPA High-speed Uplink Packet Access

IAB Internet Architecture Board

IAENG International Association of Engineers

ICT Information and communications technology

IEEE Institute of Electrical & Electronics Engineers

IETF Internet Engineering Task Force

IGF Internet Governance Forum

IIT Indian Institute of Technology

INR Indian rupees

IP Internet Protocol

ISM Industrial, scientific, and medical

ISOC Internet Society

ISP Internet service provider

ITU International Telecommunications Union

Kbps Kilobit per second

Km2 Square kilometre

KYC Know your customer

L&R Licensing and Regulation

LAN Local area network

LMSC Last-mile satellite connectivity

LoI Letter of intent

LRK Little Rann of Kutch

MAN Metropolitan area network

MEIRP Maximum Effective Isotropic Radiated Power

MHz Megahertz

MIIT Ministry of Industry and Information Technology

MIMO Multiple input, multiple output

MLV Medium-large villages

mW Megawatt

NCBC National Commission for Backward Classes

NFAP National Frequency Allocation Plan

NGO Nongovernmental organisation

NIC National Informatics Centre

NTIA National Telecommunications and Information Administration

NTG New Technology Group

NTP National Telecom Policy

NYU New York University

OFDMA Orthogonal frequency-division multiple access

OTP One-time password

PBG Performance bank guarantee

PoP Point of presence

RF Radio frequency

RFC Request for comments

RISP Rural Internet service provider

RLAN Radio local area network

SDR Software-defined radio

SMS Short Message Service

SVB Small villages and below

SACFA Standing Advisory Committee on Radio Frequency Allocation

Test-Bed Spectrum Sharing Innovation Test-Bed

TPC Transmit power control

TRAI Telecom Regulatory Authority of India

TSP Telecommunications service provider

TTC Tibetan Technology Centre

TVWS TV white space

UASL Unified Access Service License

UHF Ultra high frequency

UMTS Universal Mobile Telecommunications System

UN United Nations

U-NII Unlicensed National Information Infrastructure

USF Universal service fund

USOF Universal Service Obligation Fund

UWB Ultra-wide band

VLV Very large village

VOIN Villages of India Network

VoIP Voice over Internet Protocol

W2E2 Wireless Women for Entrepreneurship & Empowerment

W3C World Wide Web Consortium

W4C Wireless for Communities

WAS Wireless Access System

W-CDMA Wideband Code Division Multiple Access

WCN Wireless community networks

Wi-Fi Wireless Fidelity

WiMAX Worldwide Interoperability for Microwave Access

WLAN Wireless local area network

WLL Wireless in local loop

WMNT Wireless mesh networking technology

WPC Wireless Planning and Coordination Wing

WRC World Radiocommunication Conference

This book was produced by FGV Direito Rio,
composed with the font family Gotham, in 2017.

The **Authors** of the analyses featured in this volume are (in alphabetical order): Luca Belli, Sarbani Banerjee Belur, Peter Bloom, Anriette Esterhuysen, Nathalia Foditsch, Maureen Hernandez, Erik Huerta, Mike Jensen, Meghna Khaturia, Michael J. Oghia, Nanditha P. Rao, Carlos Rey-Moreno, Ritu Srivastava, Steve Song, Karla Velasco, Bruno Vianna.

This book is the **Official 2017 Outcome** of the **UN IGF Dynamic Coalition on Community Connectivity (DC3)**. DC3 is a multistakeholder group, fostering a cooperative analysis of the community network model, exploring how community networks may be used to improve connectivity while empowering Internet users. This volume explores the benefits of community networks, analysing case studies, focusing on the challenges and opportunities for these networks and putting forward concrete recommendations for their development.

The book includes the updated version of the **Declaration on Community Connectivity**, which was elaborated through a multistakeholder participatory process, facilitated by the DC3. The Declaration emphasise that community networks are crowdsourced networks "*structured to be open, free, and to respect network neutrality. Such networks rely on the active participation of local communities in the design, development, deployment, and management of shared infrastructure as a common resource, owned by the community, and operated in a democratic fashion.*"

"*Community networks provide access where traditional or commercial networks do not reach or serve.* [...] *We need to put our minds and energies together to forge new partnerships, strengthen existing ones, and support every-day heroes around the world who are changing the way connectivity is deployed. We can all support community networks in our own way*"

Kathryn Brown,
President and Chief Executive Officer of the Internet Society

"*This book and the work of the UN IGF Dynamic Coalition on Community Connectivity represent a very positive example of how crowdsourced efforts can positively contribute to the identification and sharing of knowledge and good practices, leading to a more connected and empowered society.*"

Jan Dröge,
Director of the EU Broadband Competence Offices Support Facility

Agência Brasileira do ISBN
ISBN 978-85-9597-010-6
9 788595 970106

This book was published thanks to the generous support of the Internet Society