

Closing the Access Gap:

Innovation to Accelerate Universal Internet Adoption



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1 Preface

“Significantly increase access to information and communications technology and strive to provide universal and affordable access to the internet in least developed countries by 2020”

– Sustainable Development Goal 9c

Roughly four billion people globally have yet to adopt the internet. By including internet access in the Sustainable Development Goals (SDGs), the global community is committed to expanding access and promoting adoption.

As governments, donors, think tanks, and others try to understand how to achieve the SDGs, a significant body of work on barriers and progress toward internet access and adoption is expanding. The Digital Impact Alliance (DIAL) commissioned this paper to understand potential business model and technology innovations for accelerating access and adoption of mobile phones and the internet in emerging markets and inform the development community of innovations underway, as well as lessons emerging from these efforts. Questions examined include:

- Are these innovations purely operating at the margins, or might some have the potential to disrupt traditional business models?
- What role do such innovations play in a strategy to achieve broader access and adoption within an emerging market?

- What is required to foster a more enabling environment for promising access and adoption innovations?

The analysis suggests that although a “silver bullet” is unlikely to emerge, there is a clear role for business model and technology innovation, and the financing mechanisms to support such developments.

The analysis also suggests that although a good deal of government, industry, and development community activity is underway, independent, uncoordinated actions are unlikely to succeed in solving this development challenge. Instead, coordinated collective action is needed. Working together, the global community can make *“universal and affordable access to the internet in least developed countries”* a reality.

2 Executive Summary

“...Entirely new approaches and innovative business models may be needed ...to achieve universal coverage of broadband.”

The Broadband Commission. The State of Broadband. 2015¹

Mobile and internet services have the power to transform lives, offering life-enhancing financial, health, and many other services, as well as the simple ability to express oneself to one's family and community. Yet millions of people in emerging markets lack access to these services, and even those who have access often do not adopt services, because of constraints arising from limited affordability, perceived value, and ability to use the services. The resulting access and adoption gaps threaten to exacerbate existing economic and social inequities facing low-income, rural communities in emerging markets, particularly among women and girls.

The market alone will not close the access gap. Over time, industry investment in mobile and fixed networks in the developing world may increase and extend existing network coverage, but will likely not expand to connect marginalized populations in unconnected and under-connected geographies because of the high capital and operational costs and low profit potential. This market frontier, or the point at which economic incentives to expand and deliver connectivity fall to zero, will for the foreseeable future leave hundreds

of millions of people unconnected as they reside beyond the point at which current service delivery, via the dominant model of network operators, makes economic sense.

This is where innovation has a role to play. A growing set of non-traditional service providers are testing new business models and technologies to reach consumers who otherwise might reside beyond the market frontier. Thus far, few, if any, of these innovations have yet to reach the type of scale that are

1. Broadband Commission for Sustainable Development. *The state of broadband 2015: Broadband as a foundation for sustainable development*. Geneva: ITU; 2015. Available at: <http://www.broadbandcommission.org/publications/Pages/SOB-2015.aspx>

substantially shifting the access and adoption equations. These diverse efforts, however, are important as industry, governments, and the development community explore how to close this gap.

To address the access gap, academics, technologists, and entrepreneurs, from major Silicon Valley firms to start-ups in rural Mexico, are testing new business models and technologies to extend the reach and affordability of mobile and internet beyond what the current mobile footprints and business models support. Though these models all address the basic issue of internet access and adoption, they approach the challenge in quite different ways, providing a variety of potential solutions that may or may not be appropriate for a given market. A review of some recent and ongoing efforts provides both a framework to help decision makers consider where innovation can best address gaps in their specific contexts, as well as some lessons and opportunities for action across the ecosystem. The following are the three main conclusions:

- 1. A portfolio of diverse, innovative access solutions is required to meet unique market contexts.** A range of innovative models are beginning to serve communities at the base of the economic pyramid. It is unlikely that a single “silver bullet” will emerge to close the access gap for billions of people across dozens of markets. Each model offers features that are

appropriate in specific markets, but no single innovation will apply in every context. Market dynamics, geographic conditions, regulatory constraints, and community characteristics all play a role in the potential success of different business models and the applicability of different technologies. To enable this portfolio to emerge, governments, donors, industry and investors all have a role to play in supporting greater innovation and experimentation to identify and accelerate scale-up of sustainable solutions.

- 2. An active community of innovators is implementing solutions, but many require risk capital to fully explore alternative business models.** The business case for last-mile innovations for the most marginalized populations is still to be determined given the high costs for deployment and currently low profit potential. To help support entrepreneurs innovating for the last mile, risk capital is needed to help offset immediate infrastructure costs but must be carefully structured to avoid dependency. Although industry will remain the chief source of investment in the sector, governments, bilateral donors, and impact investors have key roles to play in supporting innovation. Governments, donors, industry, and investors can all play roles with greater support through appropriate financing and risk capital, which

supports testing of new business models and technologies.

- 3. Greater collaboration and knowledge sharing across the community, within bounds of market competitiveness, can play a role in accelerating innovation.** Both innovators and investors alike require more actionable market intelligence (for example on end users, geographic characteristics, existing infrastructure, and regulatory constraints) in order to tailor different market models. The type of market data commonly used to base investment decisions in mature markets is more expensive and difficult to obtain in low-resource environments. Most innovators, particularly smaller actors, struggle to navigate regulatory, technical, and financial challenges on their own, as well as to understand and foster the demand-side drivers needed to drive low income end user adoption. Both innovators and investors alike are hungry for better knowledge and more data and what works for different models. Greater government and donor investment to support research and knowledge sharing can help address these gaps and uncover these data.

IMPLICATIONS FOR ACTION

To realize the potential growth and adoption of innovation in this sector, a range of market participants all have roles to play.

In addition to creating constructive enabling environments to expand traditional network connectivity in their countries, *policymakers* can consider how their policies and regulations encourage innovation, as well as provide risk capital in the form of grants or short-term subsidies to enable small companies or social enterprises to test the viability of potentially game-changing access innovations. Access innovations are blossoming in policy environments that foster competition, provide flexible and streamlined licensing, and are open to trials and experimentation. *Innovators*, including start-ups and forward-looking traditional operators, can learn from prior telephony and internet expansion efforts where history demonstrates that simply building infrastructure is not enough; thoughtful distribution that improves affordability and strengthens the incentives and ability of low-income end users to adopt service also is required to support economically sustainable models.

Bilateral and multilateral *donors and other investors* have an opportunity to accelerate adoption by providing risk capital to enable promising, early-stage innovations. Market-based finance will be the key driver of sustainable, large-scale connectivity, but many potentially interesting models are at risk of being lost to the ‘valley of death’ between proof-of-concept and positive cash flow. *Access advocates*—comprising the growing set of global alliances, advocacy

groups, academics, donors, NGOs, and corporate policy shops—can enhance their voices and effectiveness through stronger coordination.

Finally, given the magnitude and complexity of the challenge, governments, innovators, donors, and other investors, as well as access advocates, may want to consider a more coordinated approach to testing the viability of these innovations, including greater investment in testing such models, and more structured approaches to undertaking and sharing data and insights. By establishing clear definitions of success, identifying areas of respective comparative advantage, harmonizing research agendas, and improving knowledge sharing, these groups can help accelerate sustainable access for and adoption by the underserved.

3 The Current Access Landscape

Access to the internet (defined as the necessary conditions of network coverage, affordable price levels, and user agency with skills, resources, and interest) can result in economic and social benefits for wealthy and low-income consumers alike.² The full benefits of the mobile revolution will not be realized until all members of society have access to networks and services that are relevant and affordable.

Industry will continue to play a key role in extending traditional mobile networks to the last mile, while policymakers and regulators can focus on creating optimal environments for the market to expand as deeply across a population as possible. Network coverage to some rural, or marginalized, communities may never make economic sense to serve via traditional networks and business models, however, even in the most supportive policy environments. At some point in every market, commercial investment hits a “**market frontier**,” or the point at which economic incentives to expand and deliver service fall to zero, where industry’s cost-to-serve each incremental new user—much less to design service to meet low-income, underserved consumer segments—intersects the willingness or ability of the new user to pay for service.³

Given this, policymakers and regulators play critical roles in fostering enabling environments that push the market frontier, expanding the market’s ability to serve lower-income, low-density consumers who currently lack access or see value in adopting services where they exist. Even the most progressive policies, however, run up against the limits of the existing economics of traditional services. This is the point at which business model and technology innovation is required.

Governments, industry, donors and others with an interest in achieving global goals relating to phone and internet access might consider a variety, or portfolio, of different solutions, whereby policy facilitates the expansion of existing network coverage, while business model and technology innovations help to reach rural, low-income communities.

2. See for example https://www.itu.int/ITU-D/treg/broadband/ITU-BB-Reports_Impact-of-Broadband-on-the-Economy.pdf and <http://www.worldbank.org/en/publication/wdr2016>

3. World Bank. Telecommunications and Information Services for the Poor: Toward a Strategy for Universal Access. *World Bank Discussion Paper No. 432*. April 2002.

3.1 CURRENT FORMS OF ACCESS AND ADOPTION

In developing countries, mobile networks are the dominant access technology, with mobile operators purchasing spectrum licenses, deploying networks of cell towers, and selling predominantly pre-paid, airtime and data via agent networks. Mobile phones—basic, feature phones, and smartphones—are increasingly available and affordable. The combination of the portability of a handset and broad network coverage provides the user with mobility.

Mobile carrier networks have been deployed globally over the last 25 years and the regulatory, technical, and commercial structures such as broadband spectrum licensing are well established. Cell networks provide wide areas of coverage from single cell sites compared with technologies such as Wi-Fi; access to the internet is typically unrestricted and open. Globally, 2G coverage is widespread, with 90 percent of the world's population covered.⁴

The business case for expanding coverage into rural regions is challenging, however. The high capital expenditure (CAPEX) and operating expenditure (OPEX) costs associated with mobile carrier networks, including costly spectrum licensing fees, lead to deployments focused on densely populated, urban, and peri-urban

environments. Where service might be available, prices can be unaffordable to low income populations in emerging markets. As a result, urban 3G population coverage is 89 percent but only 29 percent for rural regions.⁵ Although 2G coverage is widespread, global coverage of higher speed 3G is lower at 70 percent,⁶ and 4G is 35 percent.⁷ As a result, even where low-income users are able to afford service, they often face a far inferior user experience, relying mainly on slower 2G service. A recent GSMA report estimates that compared to urban cellular site deployments, rural and remote tower site location can cost up to 30% more in CAPEX, up to 100% more in OPEX (driven by increased energy and backhaul costs), while serving 80% less users per site, and resulting in 95% less revenue.⁸

4. GSMA, "Closing the coverage gap – a view from Asia." June 2015.

5. ITU, "ICT Facts and Figures - The World in 2015." Posted at <http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2015.pdf>. Accessed December 2015.

6. GSMA, "Closing the coverage gap – a view from Asia". June 2015.

7. GSMA, "4G Networks to Cover More Than A Third of Global Population This Year." Posted at <http://www.gsma.com/newsroom/press-release/4g-networks-to-cover-more-third-of-global-pop-this-year/>. Accessed December 2015.

8. GSMA, *Unlocking Rural Coverage: Enablers for commercially sustainable mobile network expansion*. <http://www.gsma.com/mobilefordevelopment/programme/connected-society/unlocking-rural-coverage-enablers-commercially-sustainable-mobile-network-expansion>. July 2016.

3.2 CONVERGENCE OF TRENDS AND TECHNOLOGIES DRIVING THE EMERGENCE OF NEW ACCESS INNOVATIONS

Fortunately, a range of business model and technology innovations are emerging in the marketplace that address supply and demand barriers to access and adoption along the network map. Academics, technologists, and entrepreneurs are testing new business models and technologies to extend the reach and affordability of mobile and internet beyond what the current mobile carrier footprints and business models support. Four trends are converging to drive the emergence of new access innovations.

1. A proliferation of pilots and demonstrations are testing new business models and technologies. (See Appendix 1 for headlines on a non-comprehensive set of 42 examples.) The wide range of access innovations being tested and the number of pilots and trials increase the likelihood of uncovering sustainable, low cost access solutions.
2. Widespread access to Wi-Fi-enabled devices, particularly mass adoption of smartphones, is enabling access innovations that utilize Wi-Fi. Companies like Project Isizwe (see Appendix 2 for case studies) have been piloting free Wi-Fi to increase internet usage among first-time users in South Africa, while companies like

poa! Internet are blanketing Kibera in Nairobi with coverage from Wi-Fi hotspots. Wi-Fi, especially free and/or shared Wi-Fi, can reduce the cost of data usage, increasing the affordability for underserved demographic segments.

3. Thirdly, the reach and capacity of both international and national fiber networks are expanding. Where financially possible, fiber makes last mile access innovations better, more reliable, less expensive, faster, and ideally, more open and competitive. Fiber is an enabler for new access innovations. For example, Google's Project Link provides fiber backhaul as a neutral wholesaler, sharing the infrastructure across multiple internet service providers (ISP) and mobile operators in parts of Uganda and Ghana. FibreCo in South Africa offers a similar open access network. This changing landscape whereby an operator does not need to own international, national, and local backhaul networks means new entrants can address specific parts of the value chain.
4. Finally, global companies with significant scale and resources are testing new approaches to extend access to under and unconnected populations. Microsoft is leading the charge on TV white space (TVWS), particularly with its partnership with Mawingu Networks.

Google is testing the provision of coverage from high-altitude balloons through Project Loon. Facebook has similar efforts with solar airplanes via Internet.org. LeoSat, OneWeb, and Space X are launching flotillas of low earth orbit (LEO) satellites to provide ubiquitous global coverage. All of these firms have economic incentives for their investments that differ from that of traditional mobile operators. This wave of new players has the potential to complement and/or disrupt the mobile networks status quo.

The convergence of these trends, and the increasing complexity in the access landscape, highlight the importance of researching and understanding the portfolio of emerging, new access innovations.

BOX 1: THE ANATOMY OF A NETWORK

In general, mobile phone and internet networks feature core networks, backhaul, and last mile.

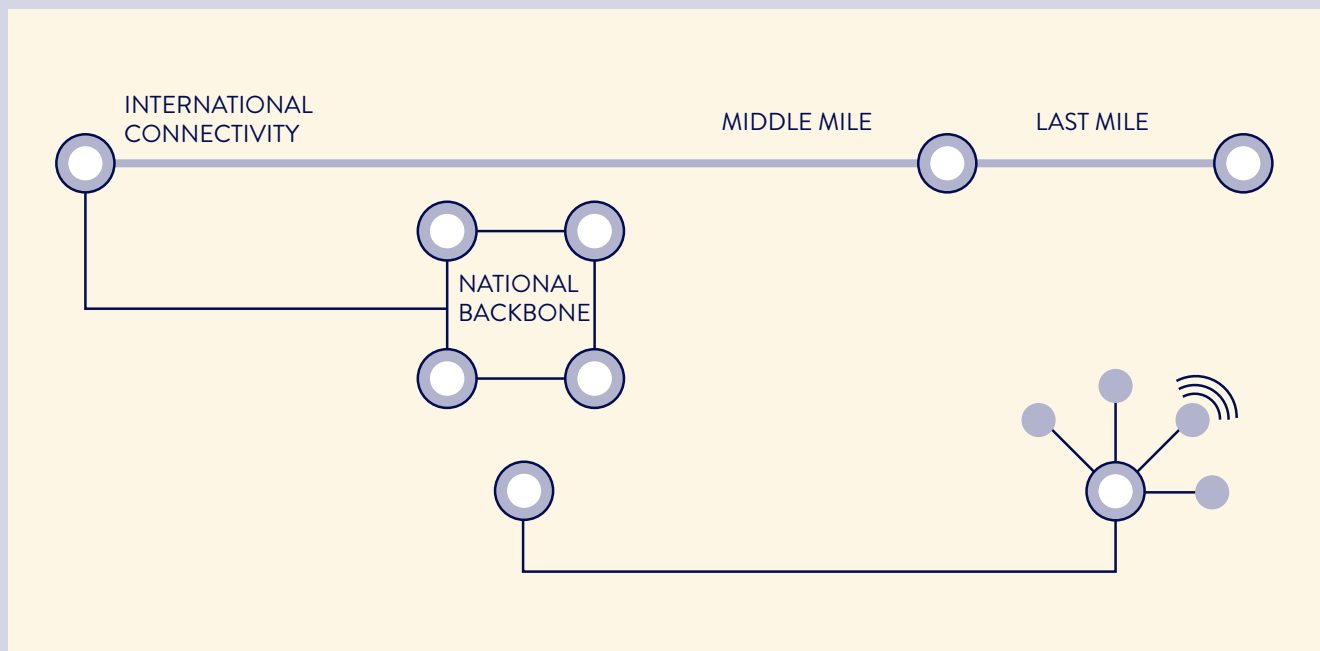
Core networks (including national backbone and international connectivity) encompass the high-capacity fiber optic infrastructure delivering traffic to/from aggregation points (e.g., Internet Exchange Points, IXPs), peering connection points between Tier 1 Service Providers, and submarine cable landing stations for international connectivity.

Backhaul (or middle mile) refers to the infrastructure carrying voice and data traffic from an operator's core network to an aggregation site, such as a base station. Backhaul often is the key barrier to supplying coverage particularly to areas featuring low-density or challenging topography such as islands or mountains.

Fiber is the most common form of backhaul, offering the highest capacity and best quality service, but often is prohibitively expensive to deploy in rural or topographically difficult areas,

given the costs associated with obtaining rights of way and construction permits. Microwave often is used in areas where fiber is too expensive, but it requires line-of-sight between transmitters, so it too can be prohibitively expensive in very remote areas. Satellite backhaul overcomes the rural challenges of distance and topography, but has high operating costs and often lower quality service than traditional fiber.

Last mile refers to the connection from an aggregation site to an end user, be it an individual in a household or a school or business. Providers deliver last mile service via traditional mobile phone radio or alternative channels such as Wi-Fi. Beyond pure infrastructure, a mobile operator or internet service provider also must invest to ensure a viable distribution network is in place, such as agents selling airtime, as well as sources to sell and service locally appropriate handsets.



4 *Last Mile Access Innovations*

The entry of new players in this market shows an increasingly diverse range of business models and technology innovations. The term “access innovations” provides a framework to categorize the range of approaches and to understand and highlight the different methods of last mile access. Last mile access innovations typically refer to those that close the gap between an aggregation point, such as a cell site, and the end user.

Innovation may or may not involve new technology, but in either case, requires reimagining business models, including everything from cost and pricing structures to sales and marketing to handset considerations. Some access innovations rely on existing mobile and internet networks and offer innovative business models that aim to address barriers to access and adoption by the underserved. Other innovations also incorporate new or new use of existing technologies to address the economics of extending the network to the last mile, ranging from cached content delivered via Wi-Fi to high-altitude solutions such as satellites, balloons, and solar powered airplanes.

Regardless of the approach, technology and supply-side solutions are not enough; sustainable business models—not to mention social impact—require affordable service, sufficient local content, and relevant services to attract and retain users, and ways to generate sufficient awareness and skills among underserved users. A robust approach to

fostering demand is integral to success for any access innovation.

In addition to distinguishing the role of new business models and/or technologies, definition of the last mile delivery challenges each innovation can address provides a useful way to categorize innovations. While all ultimately may have roles to play in closing the last mile, they address challenges at different points along the network. Figure 1 offers a framework for these categories, followed by greater description on the next page.

Table 1 offers a way to categorize emerging access innovations, describing some of the common technology and business model features commonly found among examples underway.

4.1 MODELS TO EXTEND INFRASTRUCTURE

One type of innovation seeks to extend existing network infrastructure to communities where backhaul is limited as a result of traditional service providers not anticipating economically viable

FIGURE 1: NEW ACCESS MODELS GROUPED BY “ACCESS CHALLENGE”

| Lack of network coverage: extending infrastructure | Lack of affordability where connectivity exists: complementary technologies | Lack of relevance and familiarity where connectivity exists: improving value |
|---|---|---|
| <p>Network expansion to rural communities without existing network coverage, but with backhaul options (satellite; microwave or TVWS to fiber). Examples include Mawingu, Rhizomatica, and ViRural.</p> | <p>Alternative internet service delivery to marginalized communities already within coverage, but dominant models are not fully serving the base of the pyramid customers, such as with poa! Internet's and Project Isizwe.</p> | <p>Access models leveraging existing devices and access technologies, shifting burden of willingness to pay, such as with Free Basics and Gigato.</p> |

Source: Caribou Digital⁹

means of providing connectivity. The models employ a range of technologies to extend the network, such as Wi-Fi or microwave, but are most distinguished by their business models’ innovations, including different ownership, partnership, and management structures that affect the relationship with, and value proposition for, end users.

Extending Infrastructure: Rural ISP

In areas where mobile network operators are not present, entrepreneurs are developing internet service delivery models leveraging Wi-Fi for last mile access connectivity to anchor tenants and direct to individuals. These models often feature low cost networking equipment, with backhaul connectivity provided either by microwave links or satellite. The lower CAPEX and OPEX requirements are supported by monthly

average revenue per user (ARPU) in the US\$3–US\$5 range. “Anchor tenants” refers to organizations with sufficient demand and resources to merit service provider investment in a given geographic area, such as local government offices, agricultural processing enterprises, and tourist facilities.

Extending Infrastructure: MNO-partnership model

The high CAPEX and OPEX costs associated with mobile carrier networks leads to deployments focused on densely populated, urban/peri-urban environments. However, approaches such as sharing of mobile network infrastructure and deployment of lower cost, “white labeled,” networking equipment by nontraditional service providers can reduce costs and facilitate network expansion.

9. <http://cariboudigital.net/new/wp-content/uploads/2016/08/Caribou-Digital-DFID-Digital-Access-in-Africa.pdf>

TABLE 1: TECHNOLOGY AND BUSINESS MODEL CHARACTERISTICS OF ACCESS INNOVATIONS

| | | TECHNOLOGY CONSIDERATIONS | | | |
|--|--|---|--------------------------|--|---|
| | | Access Devices | Access Network | Backhaul Technology | Spectrum Licensing |
| Extending Infrastructure: Network expansion to rural communities without existing network coverage, but with backhaul options (satellite; microwave or TVWS to fiber) | Rural Internet Service Provider (ISP) | Wi-Fi enabled devices (feature phones, smart phones, tablets) | Wi-Fi / TVWS | Various options depending on availability, cost and regulatory constraints (fiber, satellite, TVWS, microwave) | Licensed-exempt Wi-Fi |
| | MNO-partnership model (revenue sharing or wholesaler) | GSM-enabled phones (basic, feature, smart) | Licensed mobile networks | Various options depending on availability, cost and regulatory constraints (fiber, satellite, TVWS, microwave) | Licensed |
| | Microtelco/Community GSM | GSM-enabled Phones (basic, feature, smartphone) | GSM | Microwave or satellite | Use of GSM outside of traditional license (e.g., “social purpose spectrum”) |
| Complementary technologies: Alternative internet service delivery to marginalized communities already within coverage, but dominant models are not fully serving the base of the pyramid customers | Paid Commercial Wi-Fi | Wi-Fi enabled devices (feature phones, smartphones, tablets) | Wi-Fi | Predominantly fiber | Licensed-exempt Wi-Fi |
| | Subsidized, Free Public Wi-Fi | Wi-Fi enabled devices (feature phones, smartphones, tablets) | Wi-Fi | Predominantly fiber | Licensed-exempt Wi-Fi |
| | Shared Access Centers | Desktop computers, laptops, tablets, internet-enabled phones (feature, smartphones) | Ethernet/ Wi-Fi | Various options depending on availability, cost and regulatory constraints (fiber, satellite, TVWS, microwave) | None |
| Improving value: Access models leveraging existing devices and access technologies, shifting burden of willingness to pay. | Zero-Rating | GSM-enabled Phones (basic, feature, smartphones) | Licensed mobile networks | Relies on mobile carrier network | Licensed |
| | Sponsored/ Earned Data | GSM-enabled phones (basic, feature, smartphones) | Licensed mobile networks | Relies on mobile carrier network | Licensed |

TABLE 1: TECHNOLOGY AND BUSINESS MODEL CHARACTERISTICS OF ACCESS INNOVATIONS

| | | BUSINESS MODEL | | |
|--|--|---|---------------------------------------|---|
| | | User Pricing | Sales & Distribution | Examples |
| Extending Infrastructure: Network expansion to rural communities without existing network coverage, but with backhaul options (satellite; microwave or TVWS to fiber) | Rural Internet Service Provider (ISP) | Varies (metered/sachet pricing; monthly subscription; anchor tenant supported) | Community network agent model | Mawingu, AirJaldi |
| | MNO-partnership model (revenue sharing or wholesaler) | Full-fare, metered usage, predominantly pre-pay for calls, SMS, or MB of data | Agent network | Africa Mobile Network, Vanu, ViRural |
| | Microtelco/Community GSM | Varies (metered/sachet pricing; monthly subscription, pre-pay for each call/SMS; anchor tenant supported) | Community network agent model | Rhizomatica, Endaga (formerly), Village Telco |
| Complementary technologies: Alternative internet service delivery to marginalized communities already within coverage, but dominant models are not fully serving the base of the pyramid customers | Paid Commercial Wi-Fi | Full-fare, metered usage for MB of data | Staff at hotspot and agent network | poa! Internet, Roke Telecom, Everylayer |
| | Subsidized, Free Public Wi-Fi | Free via gov't or corporate subsidy; limited usage | None | Project Isizwe, Facebook Express Wi-Fi |
| | Shared Access Centers | Free or partially subsidized via government and donors/ NGOs, limited usage | None | Community knowledge centers |
| Improving value: Access models leveraging existing devices and access technologies, shifting burden of willingness to pay. | Zero-Rating | Free for select content, subsidized by mobile operators or app developers | Partner mobile operators & app stores | Free Basics |
| | Sponsored/ Earned Data | Free for select content, subsidized by mobile operators or app developers | Partner mobile operators & app stores | Gigato |

New hardware and software solutions often enable these innovations: whereas base stations once cost upwards of US\$100,000, simple, lower volume base stations using open source software now can cost as little as US\$10,000.¹⁰ Access to appropriately priced spectrum, particularly digital dividend spectrum, spectrum band vacated by analogue television station broadcasts in the transition to digital television broadcasting can provide balance between capacity and geographic coverage. Healthy market competition, with multiple competing mobile operators and limited government ownership can lead to competitive consumer benefits in the form of pricing and service options for users.

A number of new entrants are demonstrating potential profitability in low population-density deployments with sufficient revenue to cover lower cost CAPEX deployments. By financing their own network deployment, these organizations reduce traditional operators' financial risk. The new entrants tend to partner with operators either through revenue-sharing agreements (essentially acting as an extension of the main operator) or as a wholesale network, supporting multiple operator access networks.

Extending Infrastructure: Microtelco/Community GSM

Micro-telecommunications (or microtelco) /community GSM providers offer small-scale, lower-cost network solutions that link to traditional backhaul with the purpose of bringing voice and SMS services (and in some cases internet) to remote, rural areas outside of the coverage footprint of mobile operators, by leveraging ownership and operation of the network by the community.¹¹ Networks typically use spectrum without a license, or with special dispensation from the regulator.

Remote, rural regions where GSM network build-out is unlikely are suitable locations for community-owned networks as well as supportive regulatory environments that provide allowances for use of GSM spectrum without a license. In some instances, to varying degrees, these innovations feature local ownership and/or operation of the network, which provides incentive to develop the network.¹² As members of a local community operate the network, some of the revenues generated remain with the community and a sufficient software management system is critical to allowing community members to run the network.

10. Heimerl, K. Hassan, S. Kashif, A. Brewer, E. Parikh, T. Local, Sustainable, Small-Scale Cellular Networks. ICTD 2013 Proceedings of the Sixth International Conference on Information and Communication Technologies and Development: Full Papers - Volume 1. 2013.

11. Galperin, H. Bar, F. "The Microtelco Opportunity: Evidence from Latin America." *Information Technologies and International Development*, 3 (2). 2006. Heimerl, K. Hassan, S. Kashif, A. Brewer, E. Parikh, T. "Local, Sustainable, Small-Scale Cellular Networks." ICTD 2013 Proceedings of the Sixth International Conference on Information and Communication Technologies and Development: Full Papers - Volume 1. 2013.

12. Ibid

PROFILE 1: MAWINGU NETWORKS

Mawingu Networks is a rural internet service provider outside the 60,000 person market town of Nanyuki in Laikipia county, Central Kenya, which has approximately 300,000 to 400,000 inhabitants. The organization has employed a successful partnership strategy to attract start-up and growth capital to trial and improve its business model and use of technology, which in this case began with unlicensed TV white space spectrum and has evolved over time.

Mawingu's base stations, which are solar powered, are the first in Kenya to use unlicensed TV white space spectrum band to offer high-speed (up to 20 Mbps) internet service via Wi-Fi in a rural setting. For its pilot project, Mawingu set up eight hotspots, including in five schools, as well as the the Red Cross, public library, health clinic, and a Mawingu Kiosk available to the public. As Mawingu has expanded, it added agents who sell low-cost internet access and device charging services within their communities. The success of these hubs depends on increasing foot traffic, so agents have the incentive to market the value of their services to the wider community. The price to end users is low, beginning with a price of roughly US\$0.50 for 24 hours (300 MB cap), US\$1 per week (500 MB cap), US\$3 for one month (2 GB), or US\$10 for a three-month package (8 GB), and device charging.

Mawingu has knit together a diverse set of partners that have enabled its initial project. Its early days featured grants from Microsoft's 4Afrika

initiative and USAID, in part to test the ability to develop a model using TV white space spectrum and technologies. Subsequently, Mawingu was able to attract funding from investors, including Vulcan, Inc. and private investor, Jim Forster. Ultimately, the approach appealed to the Overseas Private Investment Corporation (OPIC), which committed to providing a US\$4.1 million loan in September 2016 to enable commercial expansion of Mawingu's model further across Kenya.

See Appendix 2 for more details on Mawingu Networks.

Community-owned networks succeed in communities where there is an existing, strong social structure.

The key challenge with community-led models is the level of effort required to recruit and train communities to invest in and operate the network. This high-touch approach may limit the scalability, but may be suitable if deployed in partnership with existing NGOs or community groups that have the community mobilization infrastructure already in

place. Communities must maintain and operate the network on an ongoing basis, and companies that offer such solutions are early stage businesses that can face challenges to deploy large-scale networks.

Scale-up itself could pose an additional challenge for microtelco/community GSM networks operating without dispensation from the regulator for spectrum, in the form of regulatory uncertainty. If microtelco/community GSM networks scale, there may be a risk

of obstruction from mobile operators. A final trade-off is that such models typically offer voice and SMS services but no internet access.

One variation on the microtelco/ community model is to extend network reach by creating a network of Wi-Fi routers, known as a “mesh network.” Generally, entrepreneurs or community groups manage such networks, including local marketing and distribution within their communities. The Village Telco mesh network allows free local calls; a mesh network in Johannesburg had 70 percent of calls being local. Wi-Fi-enabled handsets usually are required, although technology such as the Mesh Potato allows such networks to provide voice services via basic feature phones.

Such networks can be useful, but have limits. Given the limited reach of Wi-Fi routers, the approach is difficult to deploy in very remote or widely distributed rural communities. The decentralized nature of a mesh network means there is no single point of failure. More critically, routers within these networks both transmit and receive data, but cannot do so simultaneously; as the number of routers in a network increases, the efficiency of the overall network decreases. Larger mesh networks are technically challenging to implement and require a person with sufficient technical skill to follow installation instructions. And mobility is restricted to areas of coverage around the particular router

within the mesh network.

4.2 COMPLEMENTARY TECHNOLOGIES

In many communities, traditional coverage and services exist, but are cost-prohibitive for low-income end users in the existing footprint. In these contexts, innovators are testing new business models, often using existing or emerging technologies in novel ways, to promote affordable access among low-income consumers.

Complementary Technologies: Paid Commercial Wi-Fi

Wi-Fi hotspots are operated as commercial businesses ranging from single cybercafés to networks of hotspots selling pre-pay, full-fare internet access. Wi-Fi networks utilize unlicensed Wi-Fi spectrum and provide more localized coverage compared to mobile carrier networks, satellites or high-altitude platforms (or HAPs, referring to the range of more experimental solutions for providing backhaul coverage to mobile network operators (MNO) or ISPs in rural, hard-to-reach areas such as balloons, low earth orbit (LEO) satellites, or solar-powered unmanned aerial vehicles).

Commercial Wi-Fi networks generally are most economical in densely populated urban/peri-urban environments that provide a larger user base and higher likelihood of low cost fiber backhaul.

PROFILE 2: VIRURAL AFRICA

ViRural is a U.S.-based start-up company aiming to extend phone, internet, and mobile charging services to rural African communities that lack connectivity and reliable energy solutions. On the cusp of its initial commercial deployment in Nigeria, ViRural's objective is to offer a wholesale rural network to local mobile operators via roaming agreements. This solution enables operators to extend services to small rural communities that have not yet demonstrated sufficient demand to encourage investment in traditional network extension.

ViRural relies on operator partners' existing spectrum licenses and offering roaming services on a revenue share basis. Customers use their existing phones and SIM cards to connect to the ViRural network, which interconnects to their operator as seamlessly as if they are roaming via a separate operator network. ViRural earns a share of revenue for each connection it enables, as well as revenue from the sale of scratch cards or other fees for use of Wi-Fi, device charging services at the ViRural base station container, and pay-as-you-go home electrification.

ViRural assembles off-the-shelf technology components using commercial, carrier-grade small-cell base station technology into a simple "Community Hub." Each Community Hub features a 15-foot mast, clustered alongside a 40-foot shipping container that includes a satellite or microwave dish to link to backhaul, as well as solar panels with back-up batteries to enable sufficient power to run the network, provide fee-based device charging services, and power for 100 homes at 90 watt-hours per day each. A single Community Hub can provide 7-10 kilometers of phone coverage and other services for a population up to 2,500 people.

In 2017, ViRural aims to launch its first deployment in Nigeria where regulatory constraints against active infrastructure sharing prohibit the "Wholesale" model. In collaboration with the Nigerian Telecommunications regulator, ViRural has partnered with a regional MNO for access to spectrum based on a revenue sharing scheme. In mid-2017, the Nigerian Regulator (NCC) has indicated it will repeal the ban on national roaming. ViRural's agreement with the MNO includes a clause which allows ViRural to transition to a "Wholesale" model once the regulatory issues have been addressed.

The Nigerian deployment will offer connectivity and electricity to more than 20,000 rural Nigerian communities, connecting more than 40 million people.

In addition to the Nigerian deployment, ViRural is active in more than 10 additional African Markets including Liberia where ViRural has partnered with fhi360 and Mercy Corps to provide connectivity to more than 280 rural Liberian communities in 2017.

See Appendix 2 for more information on ViRural.

Markets where mobile data costs are prohibitive for lower income user segments are attracting lower cost Wi-Fi services, particularly where there is already widespread adoption of Wi-Fi enabled handsets, i.e., feature phones and smartphones.

Wi-Fi networks use unlicensed spectrum, which remove the need for costly spectrum licenses, lowering the barriers to entry for smaller providers. As a result, Wi-Fi networks can be developed with lower CAPEX than mobile carrier networks, which can lower the cost for the user.¹³ The user is able to access services provided by the internet at relatively fast speeds in Wi-Fi covered areas. Commercial Wi-Fi hotspots generally do not require on-going public funding or subsidies.

The business case deteriorates in rural areas, however, because of lower population density, lower customer spending, lack of power and low-cost fiber backhaul. Users have to pay; therefore, access is limited by affordability. Users are also limited to accessing connectivity at the hotspot location, constraining mobility.

Complementary Technologies: Subsidized, Free Public Wi-Fi

Once exclusively found in prosperous cities of the developed world, public

Wi-Fi is beginning to expand in emerging markets. With support from government or corporate funding, Wi-Fi access is provided for free in public locations, reducing the affordability barrier and enabling users to access the internet at relatively fast speeds, such as 15 Mbps for Project Isizwe in South Africa.¹⁴ This model works best in densely populated urban/peri-urban environments where a large proportion of the target population use Wi-Fi-enabled feature phones or smartphones. These models require governments with a strong digital inclusion agenda and/or willing corporate sponsors, however, both of which often work with nonprofits with existing or prospective sustainable business models.

Wi-Fi networks use unlicensed spectrum, which removes the need for costly spectrum licenses and lowers barriers to entry for smaller providers. Wi-Fi networks also have lower CAPEX and OPEX than MNOs, potentially lowering the cost for the user.¹⁵

However, sustainability becomes a challenge as the size of the network grows and costs for maintenance increase. Access is typically limited by time or bandwidth usage; for example, Project Isizwe has a daily cap of 250 MB,¹⁶ removing the ability for the user to complete tasks of long duration.

13. EveryLayer, personal communication, November 2015.

14. Project Isizwe. "City of Tshwane Free Wi-Fi gets upgraded to 15 mbps." Posted at <http://projectisizwe.org/city-of-tshwane-free-wifi-gets-upgraded-to-15mbps/>. Accessed December 2015.

15. <http://allafrica.com/stories/201609191316.html>

PROFILE 3: RHIZOMATICA

Rhizomatica demonstrates how policymakers and regulators can encourage innovation by enabling new actors to play new roles in deploying service to underserved communities.

Rhizomatica is a non-profit that since 2012 has created a regional community telecommunications cooperative enabling low-income communities in Mexico to own and operate their own small, local mobile networks. The key to Rhizomatica's approach was gaining the Mexican regulator's approval to use licensed, but unused, GSM spectrum for community-based networks where traditional service providers choose not to operate. As a result of Rhizomatica's early networks and ongoing advocacy, as of 2015, the Mexican regulator officially allocated parts of the 850 MHz spectrum band to be designated for social use. Underserved communities that meet specific criteria are eligible to use this spectrum for community-based networks to close gaps in the traditional network.

In addition to leveraging unused spectrum, Rhizomatica's model focuses on low-cost community design, ownership and administration of the network. The community contributes the roughly US\$10,000 in CAPEX required for network installation. The local government administers the network, working with Rhizomatica to set up the network and troubleshoot problems. Rhizomatica's ground operations team provides the more sophisticated technical services, including ensuring satellite or Wi-Fi connectivity, to providing backhaul and remote network management. Individual community operate and maintain the network. A key underpinning of this approach is use of open source network management software (openBSC), as well as Rhizomatica's own open source software for community network management, providing a low-

cost way for communities to set tariffs and manage billing.

Given the low cost structure, the community gains access to, and operate, an otherwise unavailable local GSM network at an affordable rate. The revenue model—designed in part by one of Rhizomatica's early communities—features fixed, monthly membership fees that entitle users to unlimited calls within the local or any other Rhizomatica network. The monthly user fee is 40 pesos, of which 15 pesos goes towards Rhizomatica's management fees, and 25 pesos covers the community's operating costs such as electricity and internet connectivity. Users also can purchase credits to make long-distance calls using voice over internet protocol (VOIP). Any revenue generated above operating costs stays within the network or the community.

Rhizomatica's partners now include 20 active networks with over 3,000 active users per month. In addition to serving these communities and identifying others for expansion, Rhizomatica advocates with the International Telecommunications Union (ITU) and others to promote regulatory reform to allow small communities to legally utilize unused, GSM spectrum in largely remote, rural locations. Rhizomatica also continues to develop its open-source, community network management software for use with GSM implementations to enable communities to administer networks.

See Appendix 2 for more information on Rhizomatica.

Users are limited to accessing connectivity at the hotspot location constraining mobility and raising privacy issues if the hotspot is in a public location away from their homes. In rural areas, lower population density, lack of power, and lack of low-cost fiber amplify the sustainability challenge.

Complementary Technologies: Shared Access

A shared access center provides a physical location to use communications and internet via shared desktop computers typically provided for free or subsidized by government or donors/NGOs. Shared access centers can also be commercial enterprises—“cybercafés.” Shared access centers were the earliest method to extend access to low-resourced communities in cities, towns, and villages round the world, pooling the costs of devices and access in public, concentrated locations.¹⁷

This access model typically requires sufficient concentration of users around the access center. Initial models required government and/or donors/NGOs with a digital inclusion agenda to provide ongoing subsidy without which sustainability could be a challenge. Re-using existing community infrastructure such as libraries, schools, and community

centers provides a natural location where groups already meet and the provision of information and communication technology (ICT) skills training can address the poor digital literacy of users driving increased demand.

If a community is already served by a backhaul connection, the addition of a shared access center can open up that connection to a broader range of people in the community. The sharing of devices reduces the burden of the cost of device ownership and accessing a computer instead of a handset is more suitable to multitasking, content production, and e-learning activities. Furthermore, access centers provide ICT skills development through formal classes or informal learning.

The scalability and economic sustainability of nonprofit shared access is a challenge, since they demand ongoing subsidies from government or NGOs. Fixed and operating costs in rural areas can be higher if satellite is used, and those costs are spread over fewer users who access the network addressable users. The further expansion of GSM rollout and mobile phone adoption has reduced the demand, and need, for shared access centers.

16. Project Isizwe. “FAQ.” Posted at <http://projectisizwe.org/faq/>. Accessed December 2015.

17. Sey, A. Coward, C. Bar, F. Sciadas, G. Rothschild, C. & Koepke, L. “Connecting people for development: Why public access ICTs matter.” Seattle: Technology & Social Change Group, University of Washington Information School. 2013. Proenza, F.J. “Public Access ICT Across Cultures.” MIT Press. 2015. Toyama, K. Kuriyan, R. Bailur, S. Rangaswamy, N. Ratan, A. Veeraraghavan, R. Menon, D. Pal, J. Srinivasan, J. “Review of Research on Rural PC Kiosks.” Posted at: <http://www.eolss.net/sample-chapters/c15/e1-25-02-04.pdf>. Accessed January 2016.

PROFILE 4: VILLAGE TELCO

Village Telco sells a Wi-Fi-based mesh network device, Mesh Potato, to allow communities to build a mesh network that allows free local calls, long distance calls and internet access. Village Telco's customers are the people within the communities purchasing the mesh network device.

Village Telco developed the Mesh Potato product to allow people to make free local calls on their network. Village Telco does not manage any deployments but rather manufactures the technology for others to use. Most of the projects that use the Mesh Potato are small, with 10-100 service points, with the majority at the lower end of that spectrum, and operate on the fringe of existing GSM networks. Village Telco has sold about 3,000 of their first-generation device, and about 3,000 second-generation devices.

The basic service will give end users local, national and international calling and internet (with free local calls). The network required to deliver this is "plug-and-play," i.e., users should be able to set up the device easily without technical assistance, and robust enough to withstand a variety of challenging environmental circumstances.

When making a phone call, the nearest Mesh Potato talks to the next closest, which talks to the next Mesh Potato, and eventually to the destination. The mesh network can be augmented via links to internet backhaul, which allow for other services, e.g., VOIP calls and internet access.

One server is needed to provide billing and dashboard services for an administrator. These services can be run on a standard laptop computer.

Scaling mesh networks can be challenging, since the number of nodes in any given network is limited. Wi-Fi devices work on a "listen before talk" basis, e.g., given three adjacent nodes in a network, the middle node cannot concurrently listen and talk to nodes either side of it. It is possible to overcome this challenge with a dual radio, which can simultaneously listen and talk, but it becomes challenging for local network owners to implement.

See Appendix 2 for more information on Village Telco.

Also, the fixed location of the access center limits mobility, creates a privacy challenge and can restrict usage by certain groups, such as women, depending on local contextual norms around technology use.

4.3 IMPROVING VALUE

A number of actors are experimenting with business models that leverage existing networks to provide service in increments and at price points that appeal to low-income end users, increasing their willingness to try and increase use of internet services.

Improving Value: Zero-Rating

Zero-rating refers to the practice of mobile operators and internet service providers that provide a subsidy to offer free data for end users to access specific apps or services through an existing network.¹⁸ Although these types of innovations do not address connectivity gaps, they can help to address adoption barriers to users who cannot afford access, or who are skeptical of access.

Users typically get access to data and content free of charge, through subsidization of data by mobile operators and ISPs, e.g., Facebook's Free Basics.¹⁹

By partnering with mobile operators with substantial existing user bases, zero-rating can address the affordability barrier for a huge potential user base. Facebook estimates that more than one billion people can access Free Basics across Asia, Africa and Latin America.²⁰ Zero-rating and sponsored data models are software based and therefore lean to deploy in terms of infrastructure with minimal CAPEX cost.

Zero-rating presents challenges, however. First, negotiating deals with mobile operators can be time intensive, especially for smaller start-ups. Depending on the details of the zero-rating agreements between content/service providers and operators, zero-rating can distort the market through price discrimination for zero-rated services. Second, critics of zero-rating contend it violates the conventions of "net neutrality,"²¹ where zero-rating services have been blocked in Chile and in India.²²

18. Zero-Rating page. Wikipedia website. Available at: <https://en.wikipedia.org/wiki/Zero-rating>. Accessed December, 2015.

19. Internet.org by facebook. "Update to Internet.org Free Basics." Posted at <https://info.internet.org/en/2015/09/24/update-to-internet-org-free-basic-services/>. Accessed December 2015.

20. Ibid

21. Layton, R. Elaluf-Calderwood, S. "Zero Rating: Do Hard Rules Protect or Harm Consumers and Competition? Evidence from Chile, Netherlands and Slovenia." Social Science Research Network. August 15th, 2015.

22. Gigaom. "In Chile, mobile carriers can no longer offer free Twitter, Facebook and Whatsapp." Posted at <https://gigaom.com/2014/05/28/in-chile-mobile-carriers-can-no-longer-offer-free-twitter-facebook-and-whatsapp/>.

Accessed December 2015. BBC News. "India blocks Zuckerberg's free net app." Posted at <http://www.bbc.co.uk/news/technology-35522899>. Access February 2016.

PROFILE 5: poa! Internet

poa! Internet is a Kenyan based company that launched its inaugural Wi-Fi service in the low-income area of Kibera in Nairobi in May 2016.

poa's observation was that low-income, urban internet users struggle with the high costs of data bundles offered by mobile operators. poa! Internet's solution is to augment existing services with a low-cost Wi-Fi network at a lower price point, which customers can use at home or in the street, rather than having to visit a specific Wi-Fi hotspot. To further reduce costs and ensure good understanding of local consumer needs, poa! Internet employs a community-based sales and distribution model.

poa! Internet also differentiates its service by offering free access to internet content from dedicated cached content servers on the local network. poa! Internet's technology and network is enables its users to access high-speed broadband at a far lower price point than local mobile operators. The free content is blended with paid-for internet access where usage is limited by the customer's ability to pay. Internet bundles range in price from KES 10 (US\$.10 for 25 MB of downloading) up to KES 3,000 (US\$29.11 for 25GB of downloading), with the majority of purchases varying from KS10–KS100 (US97 cents).²³

poa! Internet targets customers between the ages of 18 and 25 who live in urban areas and are smartphone users. These users understand the “personal business case” for being online and typically own a smartphone but cannot afford to use their data because of expensive cellular data bundles. poa! Internet identified this demographic as potential product evangelists who could convince others to come online.

poa! Internet develops the access network technology, the proprietary local content caching system, and builds relationships with local ISPs to deliver the backhaul. The team targets localities in which the model can be implemented, adapting the business model to work with the communities to promote the service and protect network assets. They also form relationships with vendors to get the optimum cost for each access point.

See Appendix 2 for more information on poa! Internet.

23. <http://allafrica.com/stories/201609191316.html>.
<http://www.dhahabu.co.ke/2016/11/30/poa-internet-liquid-telecom-brings-free-solar-internet-kibera/>

Third, zero-rated content can often be misunderstood by first-time internet users as the internet rather than a pre-determined selection of content from the internet. Fourth, users have reported fear and suspicion about billing under zero-rated plans with concerns that they might incur data charges by “accidentally” downloading content from the wider internet.²⁴

Improving Value: Sponsored/ Earned Data

In the sponsored/earned data model, users are able to access the open internet for free provided that they either view advertisements or test different mobile applications.²⁵

PROFILE 6: GIGATO

Gigato is an example of an innovative approach to encourage greater local content generation by local developers. Gigato created a smartphone application where users earn data by using sponsored applications, helping to improve affordability in markets where data costs are prohibitive or restrictive for lower income user segments.

Gigato’s direct customers are the app developers, who typically struggle to generate new installs and monthly active users, since they tend to pay prohibitively high costs to other platforms such as Facebook and mobile ad networks to market their app. App developers can use Gigato’s platform to generate app installs and monthly active users, themselves bearing the cost of refunding data to users who install and use their sponsored apps.

Although its technology can work on any mobile network, Gigato is concentrating on India, where prepaid mobile users represent around 95 percent of the market. Gigato’s market research found that these users tend to ration data, topping up miniscule amounts on their phones for fear of hidden data costs. Gigato’s platform allows these users to earn data “recharges” by using sponsored apps, reducing data costs and enhancing the smartphone experience.

See Appendix 2 for more information on Gigato

24. Kak, A. "The Internet Un-Bundled - Locating the user's voice in the debate on zero-rating." MSc Thesis Oxford Internet Institute. 2015.

25. Gigato page. Gigato website. Available at: <http://www.gigato.co/#Gigato>. Accessed December, 2015.

5 *Developing a Portfolio of Approaches to Advance Internet Access*

Though some of these innovations might prove viable for enabling access for large numbers of low-income users, silver-bullet solutions are highly unlikely. Rather, depending on market dynamics and the policy and regulatory environment governing a community, each market is likely to require a portfolio of access innovations that will meet the needs of diverse communities. In addition to investing to test and iterate access innovations, policymakers, innovators, donors, and access advocates need to learn how to apply such innovations as they expand their portfolio of solutions to accelerate internet access to hundreds of millions of users.

5.1 IDENTIFYING OPTIONS BASED ON MARKET CONTEXT

Identifying the portfolio of solutions that may best serve a particular community will depend on the unique characteristics of the market, including definition of success, current gaps in coverage and access, the market and geographic characteristics, the availability of fiber backhaul, and the state of the device market. The following framework (Figure 2, and with more detail, Table 2) highlights some of the questions and decision drivers that should be investigated to understand market conditions.

The framework highlights the wide range of options that are appropriate for each market context, and is not intended for selecting and prioritizing a particular access innovation. Policymakers and their donor partners should provide the right conditions under which the market can deploy multiple access innovations.

5.2 *Country example: A portfolio of access innovations in Kenya*

Kenya's experience suggests how a portfolio approach can help close persistent access and adoption gaps among underserved user segments. The barriers to access and adoption vary across Kenya's landscape. The national fiber network links many of the urban centers in the southwest and coastal southeast, but becomes sparse in the more rural areas of the north and east. Higher capacity 3G coverage is available in Nairobi, Mombasa, and a few other areas, but by and large, most potential users experience more limited 2G coverage. Despite the relatively reliable infrastructure, however, many low-income users have not yet adopted the internet due to lack of affordability, lack of local content and services, and lower levels of digital literacy.

FIGURE 2: NEW ACCESS MODELS GROUPED BY “ACCESS CHALLENGE”

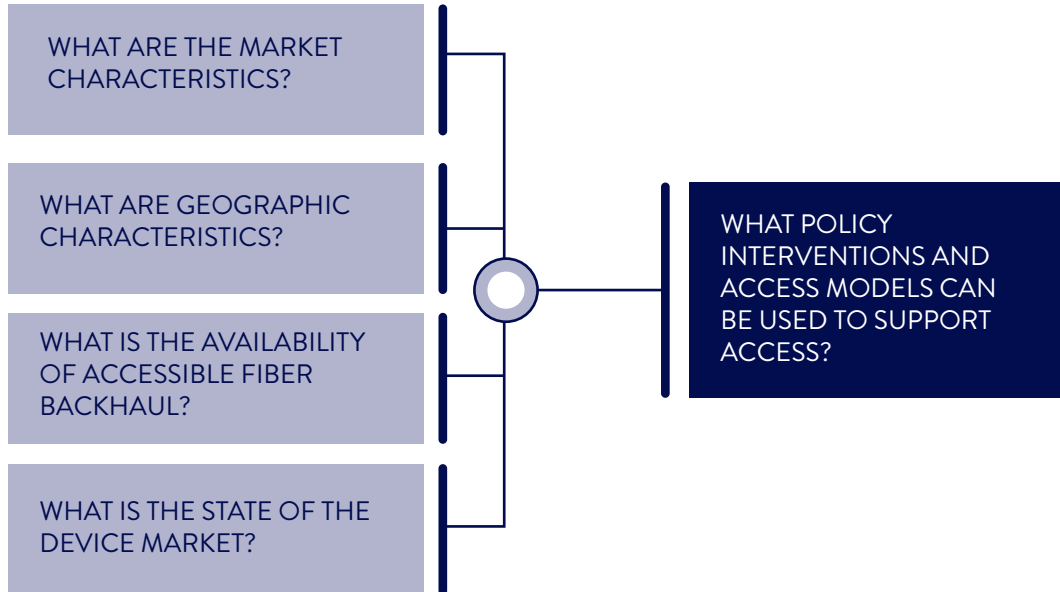
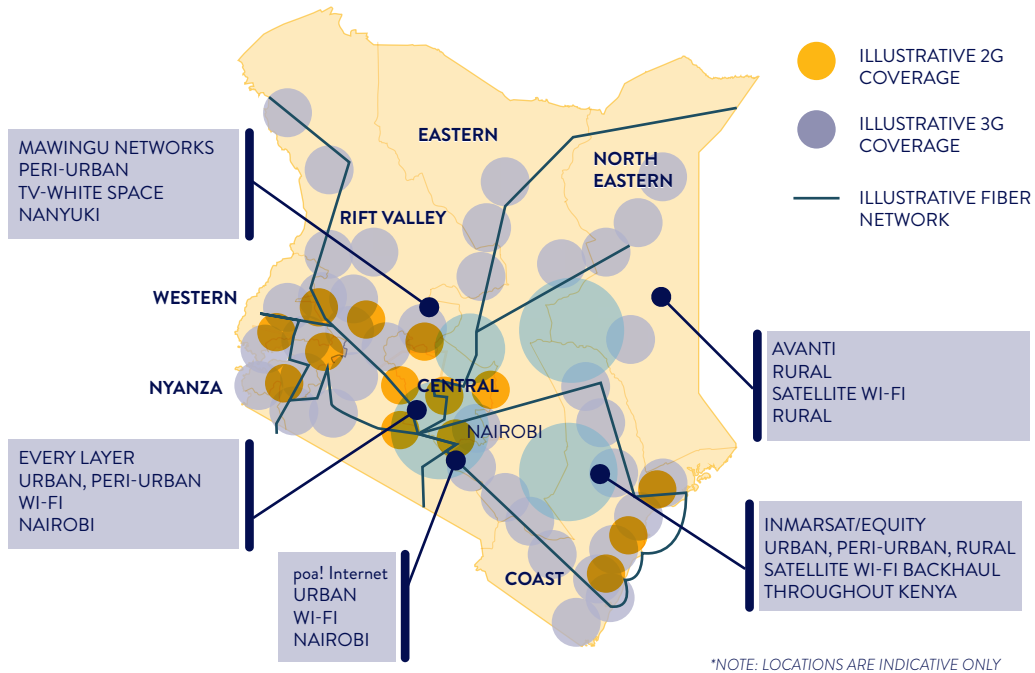


FIGURE 3: ILLUSTRATIVE MAP OF ACCESS INNOVATIONS IN KENYA



While existing mobile networks serve the bulk of Kenya's population, a variety of access innovations are being deployed to address access gaps, as the map below illustrates. Several innovations are testing how to make existing network services more attractive to low-income users. For example, poa! Internet has launched a trial offering low-cost Wi-Fi services with curated, cached content to encourage low-income users in Kibera to adopt the internet. Mawingu Networks are expanding use of TV white space-powered Wi-Fi kiosks to provide affordable service in peri-urban towns such as Nanyuki, as well as surrounding rural communities. Equity Bank partnered with Inmarsat to test the viability of offering Wi-Fi hotspots supported by satellite backhaul at their rural agent locations.

It is too early to know which, if any, of these efforts will likely prove viable for long-term scale-up, but the experience illustrates how a portfolio of innovations may help ecosystem actors to discover how to overcome the variable challenges found in a given market.

Although no single solution has yet proven itself to serve as a large-scale, economically sustainable alternative to traditional mobile and internet networks, the innovations underway are generating interesting lessons to inform ongoing efforts by industry, government, and other actors to consider.

In addition to the innovations identified above, Appendix 1 and 2 offer a non-comprehensive snapshot of 42 recent or ongoing efforts to pilot new approaches to reaching last mile users.

TABLE 2: KEY CONSIDERATIONS UNIQUE TO EACH COMMUNITY SCENARIO

| KEY FACTORS | POTENTIAL CONSTRAINTS/ CONSIDERATIONS | POTENTIAL ACCESS INTERVENTIONS (DEPLOYMENTS & POLICY) |
|--|--|--|
| <p>What are the market characteristics?</p> | <p>Market lacks competition within the incumbent, traditional mobile operators</p> | <p>Though policy interventions may be needed to spur greater competition among MNOs, rural ISP and commercial Wi-Fi models may be considered (if the regulatory environment is conducive)</p> |
| | <p>Market lacks nontraditional service providers</p> | <p>Regulatory barriers may prevent nontraditional access providers to enter the market</p> |
| | <p>Infrastructure sharing is limited</p> | <p>MNO-lead networks may be able to operate under direct contract with an established MNO partner</p> |
| <p>What are the geographic characteristics?</p> | <p>The population density of unconnected populations is high, e.g., urban environments</p> | <p>Wi-Fi models leveraging high-capacity backhaul (e.g., fiber) may be viable</p> |
| | <p>The population density of unconnected populations is low, e.g., rural environments</p> | <p>Low population density increases the cost-to-serve of network deployment and may require major anchor tenants, donor/corporate partners, and/or low bandwidth service models (e.g., microtelco/community GSM)</p> |
| | <p>Topography is challenging, e.g., islands, mountains, deserts</p> | <p>Challenging topography increases the cost-to-serve of network deployment; line of sight backhaul (e.g., microwave) may not be as suitable as TVWS or satellite.</p> |
| | <p>The market is landlocked or lacking access to core network trunkline</p> | <p>Access to international connectivity (backhaul) may be a constraint that requires policy intervention</p> |
| <p>What is the availability of backhaul?</p> | <p>Backhaul market lacks competition</p> | <p>Satellite or HAPs backhaul may be needed in lieu of policy intervention to spur competition in the terrestrial backhaul market</p> |
| | <p>Fiber is not typically deployed alongside road and power line construction</p> | <p>Deployment of fiber, or at least embedding fiber conduits, at same time as other infrastructure e.g. road building, lowers costs; may be an opportunity to encourage “dig once” legislation</p> |
| <p>What is the state of the device market?</p> | <p>Low availability of feature phones and smartphones (Wi-Fi enabled)</p> | <p>A focus on basic phone access (community GSM) and shared public internet access sites may be most viable</p> |
| | <p>Widespread availability of feature phones and smartphones (Wi-Fi enabled)</p> | <p>Widespread availability of feature phones and smartphones (Wi-Fi enabled) allows zero-rating and sponsored data, Wi-Fi-based access innovations and HAPS</p> |

6 *Conclusions and Implications for Action*

With so few innovations at a stage of development or scale to provide true evidence of what works, it remains too early to point to best practice or replicable models. Nonetheless, a few themes emerge from a review of the innovation landscape.

6.1 KEY THEMES

1) A portfolio of diverse, innovative access solutions is required to meet unique market contexts. A range of innovative models are beginning to serve communities at the base of the economic pyramid, but thus far, no single innovation has been proven to be economically viable at scale. Although anything is possible in the highly dynamic digital economy, this observation suggests that traditional mobile networks, largely supported by fiber backhaul and delivered by mobile operators, will remain the primary model for connectivity and service delivery for the bulk of the population for the near term.

That said, the traditional approach may never reach enough of the underserved, so innovations to extend access are necessary. Diverse market dynamics, geographic conditions, regulatory constraints and community characteristics all play roles in the potential success of different models. Each model offers features that are appropriate in specific markets, but no single innovation will apply in every

context. To enable and encourage a portfolio of solutions to emerge, governments, donors, industry, and investors all have roles to play in supporting greater innovation and experimentation to identify and accelerate scale-up of sustainable solutions; examples of such roles are offered below.

Policy and regulatory frameworks can support or constitute a barrier to innovative business models.

Policy environments play a critical role encouraging traditional phone and internet connectivity to expand the “market frontier,” as well as to enabling new business model and technology innovation.

Many forms of access innovations rely on regulatory environments that enable innovation. Innovators who employ solutions such as TV white space and microtelco/community GSM models need to generate proof of concept evidence to encourage supportive regulatory change. Models such as HAPS will need to address existing regulations around the safety of high altitude and unmanned aircrafts, and to operate

without interfering with existing satellite and terrestrial spectrum bands.

Flexible and conducive internet service provider (ISP) regimes can also play a role in supporting innovative models, as well as interconnection agreements that could support new GSM voice entrants and mitigate against costly termination fees.

Policies or business models that enable lower capital expenditure (CAPEX) and operating expenditure (OPEX) through shared infrastructure will jointly encourage network expansion toward the last mile.

Creating favorable economics for existing mobile operators and new entrants can help address the coverage gap.

One way to expand access in currently underserved areas is to reduce CAPEX and OPEX costs. Sharing of backhaul, ideally fiber, among multiple mobile operators, new entrants, and government infrastructure, such as military, police, schools, and post offices, reduces the cost to serve the community. An open access backhaul network available to all mobile operators and new entrants will lower costs and maximize traffic.

Sharing of towers, especially where the tower already exists (e.g., existing mobile operators, police, and electrical transmission) can materially reduce the cost to serve an area. The cost of power can be a significant portion of network OPEX; the sharing of power systems, either grid power, or diesel and solar in off-grid regions reduces these costs.

Several access innovations feature shared assets. ViRural supports sharing of infrastructure by promoting the use of a wholesale network service for multiple mobile operators in rural, underserved areas. Google's Project Link provides fiber backhaul as a neutral wholesaler, sharing the infrastructure across multiple mobile operators and ISPs. Google's Project Loon has formed a partnership with three of Indonesia's mobile operators (Indosat, Telkomsel, and XL Axiata) to provide high-speed 4G-LTE internet coverage, with the mobile operators effectively sharing Project Loon's balloon based network infrastructure. Finally, Endaga was able to lower the cost of its microtelco/ community GSM network in Indonesia by utilizing existing satellite backhaul and a power source from the local school.

Partnerships between mobile operators and last mile access innovators can lead to win-win business models.

Mobile operators have struggled to find business models that will help them recoup the high CAPEX needed to connect the last mile; partnering with last mile access innovators can help address this challenge. ViRural Africa have developed a low cost (US\$70,000–US\$80,000) rural cell tower that it finances and operates on behalf of the mobile operator in exchange for revenue share and access to mobile spectrum. Similarly, Google Project Loon is helping address the geographic challenges of connecting the many islands of

Indonesia by partnering with three mobile operators to provide backhaul and LTE network coverage. Microsoft and FLOW are partnering with USAID and the Jamaican Universal Service Fund to assess the viability of using TVWS technology to provide internet access in rural areas, as a complement to 3G/4G.²⁵ Forming mobile operator partnerships allows the zero-rating service Free Basics to provide users with free, albeit limited access, to internet services. Although the mobile operators subsidize the cost of data, “*half the people who use Free Basics to go online for the first time pay to access the full internet within 30 days,*”²⁶ which highlights the revenue benefits for the mobile operator.

2) An active community of innovators is implementing solutions, but many require risk capital to fully explore alternative business models. Though industry will remain the chief source of investment in the sector, governments, bilateral donors, and impact investors have key roles to play, both in supporting innovation and in ensuring that insights flow both to and across innovators and other actors in the access and adoption ecosystem.

Risk capital supports testing of new business models and technologies.

The early stage capital fueling the emergence of recent access innovations

has varied, including self-financing, friends and family, donor funding, and corporate partners. Regardless of the starting point, these innovations remain high-risk propositions. Most are either new or have yet to demonstrate economically sustainable business models at scale, and particularly due to the need for CAPEX, they can struggle to get to the point of demonstrating revenue potential.

Historically, mobile operators have employed traditional debt financing for their significant CAPEX costs. Risk capital from organizations such as the World Bank and International Finance Corporation (IFC) was critical to early growth of traditional mobile networks in emerging markets. Larger companies active in this space, such as Facebook, Google, and Microsoft, have significant research and development budgets to fund exploration.

Early stage companies report that financing to demonstrate revenue potential is a significant constraint, however, particularly as smaller companies are unable to raise enough capital to acquire spectrum licenses and deploy technologies such as 3G and 4G-LTE that become profitable only when deployed at scale.

Donor capital has begun to play a role toward encouraging risk capital,

25. Mitchell, P. “Microsoft welcomes US State Department Global Connect initiative.” Posted at <http://blogs.microsoft.com/on-the-issues/2015/09/28/microsoft-welcomes-us-state-department-global-connect-initiative/>. Accessed January 2016.

26. Zuckerberg, M. “Free Basics protects net neutrality.” Posted at <http://blogs.timesofindia.indiatimes.com/toi-edit-page/free-basics-protects-net-neutrality>. Accessed December 2015.

most notably with Overseas Private Investment Corporation's (OPIC) 2016 investment in Mawingu Networks,²⁷ U.K. Department for International Development's (DFID) investment in Avanti,²⁸ and the U.K. Space Agency's (UKSA) investment with Equity Bank/Inmarsat.²⁹ Often companies such as Microsoft directly fund small innovators, as is the case with Microsoft's Affordable Access Initiative.³⁰ Nonetheless, to accelerate progress to achieve the SDG target, governments, donors, industry, and investors will need to play larger roles with greater support through appropriate financing and risk capital.

Capital expenditure (CAPEX) subsidies are critical, but need to be structured carefully.

Though perhaps lower than the costs of building out fiber backhaul and mobile network towers, CAPEX is a large component of last mile access innovators' overall costs. For example, CAPEX per site can range anywhere from under US\$500 with poa! Internet to US\$70,000–US\$80,000 for ViRural Africa, with different site economics.³¹

Subsidies can help relieve CAPEX pressures so the company can address other aspects of the business to help

prove the concept. Mawingu Networks is able to offer rural customers internet access at approximately US\$1/week because of a large CAPEX subsidy on TV white space equipment, while UKSA's CAPEX subsidy to Equity Bank/Inmarsat enables testing the business case for cached Wi-Fi via satellite backhaul. Project Isizwe can offer free Wi-Fi through a government subsidy. Without these subsidies, these projects would not be able to provide affordable access to users. These approaches all require a sustainable business model, however, if they are to survive if and when their subsidies end.

3) Greater collaboration and knowledge sharing across the community, within bounds of market competitiveness, can play a role in accelerating innovation.

The type of market data that commonly informs investment decisions in mature markets is harder to come by in low-resource environments. Most innovators, particularly smaller actors, struggle to navigate regulatory, technical, and financial challenges on their own, as well as to understand and foster the demand-side drivers needed to drive low-income end user adoption.

27. Techmoran. "Kenya's Mawingu Networks receives 4 Million from OIC to turn around solar energy and provide rural wireless Internet." Posted at <http://techmoran.com/kenyas-mawingu-networks-recvies-4-million-from-opic-to-turn-around-solar-energy-provide-rural-wireless-internet/>. Accessed December 2015.

28. Avanti Communications. "Avanti Communications appointed to deliver DFID schools programme." Posted at <http://www.avantiplc.com/news-media/rns/avanti-communications-appointed-deliver-dfid-kenyan-schools-programme>. Accessed December 2015.

29. UK Space Agency. "First round of international space partnerships announced." Posted at <https://www.gov.uk/government/news/first-round-of-international-space-partnerships-announced>. Accessed November 2015.

30. <https://www.microsoft.com/en-us/affordable-access-initiative/home>

31. The coverage footprint for ViRural will be significantly greater, and lower cost compared to a standard GSM network cell tower

Both innovators and investors alike are hungry for better knowledge and more data about end users, geographic characteristics, existing infrastructure, regulatory constraints, and what works for different models. Greater government and donor investment to support research and knowledge sharing can help address these gaps.

Market data are challenging to find in low-resource environments.

Many innovators must make business model, service design, and investment decisions in the absence of reliable data on existing network infrastructure, population densities, willingness-to-pay, credit risk, electrification, and other metrics. Greater public sector effort to generate and share such data for the public good could go a long way toward unlocking private sector appetite to test these markets.

Small innovators struggle to navigate complex regulatory, technical and financial challenges.

A great deal of innovation in this sector arises from entrepreneurs who lack the influence and resources of large mobile operators or global technology companies, placing a limit on their ability to advocate for infrastructure sharing or more liberal spectrum policies. This dynamic threatens to discourage entrepreneurship and innovation from non-traditional actors. In some instances, such as with TV white space,

companies such as Microsoft share an interest and can participate in creating regulatory space and sharing lessons for the community, but in the main, few objective actors currently seek to serve the needs across companies.

Demand side barriers need to be addressed to drive adoption.

Regardless of its approach, all access innovation business models—as well as social impact—depend upon fostering sufficient adoption among consumers. Even where coverage exists, a number of demand-side barriers tend to inhibit adoption, including affordability challenges, lack of local content and services, and poor language and digital literacy.³²

Many of the ongoing access innovators are learning by doing as they foster consumer adoption. For example, providers are playing with pricing models such as free local calls, free access to a subset of internet content, and sponsored data. Innovators such as Project Isizwe and Poa! Internet attract consumers by sourcing and storing local content in a cache, reducing operating costs, and ultimately pricing. Many models address digital literacy by relying on their sales and distribution networks and/or community-based partners to guide first time users.

32. http://www3.weforum.org/docs/WEF_Internet_for_All_Framework_Accelerating_Internet_Access_Adoption_report_2016.pdf

For example, Poa! Internet looks to its agent networks and Mawingu Networks uses trusted intermediaries at schools to encourage adoption.

As is the case with most technology-based services, these innovators are learning the mix of approaches that most effective and economical through trial and error. Sharing these lessons more broadly and visibly can accelerate the collective learning curve, as can exposing innovators to NGOs and other actors who bring expertise and experience to generating demand for innovations among low-income rural populations.

6.2 IMPLICATIONS FOR ACTION

The magnitude and complexity of the internet access gap defies the ability of any single actor, or even a single segment of the ecosystem, to solve this challenge. A constellation of actors must work more intensively, creatively, and collaboratively to accelerate the pace of innovation and hence the pace of access and adoption by the underserved. In addition to working more effectively as a community, a number of opportunities exist for segments of the digital ecosystem to accelerate uptake.

In addition to creating constructive enabling environments to extend the market frontier for traditional network connectivity in their countries, *policymakers* can consider how their policies and regulations encourage innovation, particularly regarding

service and spectrum licensing, as well as consider risk capital in the form of grants or short-term subsidies to enable small companies or social enterprises to test the viability of potentially game-changing access innovations. Adopting a portfolio approach of solutions that fit a given market can help to close last mile gaps and help foster more competitive environments, with benefits for all consumers in the market.

Innovators—from forward-looking mobile operators to start-ups to other industry players looking to enter the connectivity space—will benefit from considering the lessons learned about phone and internet adoption. History demonstrates that simply building infrastructure is not enough; thoughtful distribution that improves affordability and strengthens the incentives and ability of low-income end users to adopt service also is required to support economically sustainable models.

Bilateral and multilateral **donors, as well as impact or traditional investors** have an opportunity to accelerate adoption by providing risk capital to enable promising innovations. Market-based finance will be the key driver of sustainable, large-scale connectivity, but many potentially interesting models are at risk of being lost to the “valley of death” between proof-of-concept and positive cash flow.

Access advocates—comprising the growing set of global alliances, advocacy groups, academics, donors, NGOs,

and corporate policy shops—can enhance their voices and effectiveness through stronger coordination. By establishing clear definitions of success, identifying areas of respective comparative advantage, harmonizing research agendas, and improving knowledge-sharing, these groups can help accelerate sustainable access and adoption to the underserved.

sustainable way. A more coordinated, data-driven approach to testing, demonstrating, and scaling economically viable, high-impact access innovations is an important, concrete step on this collective journey.

6.3 CONCLUSION

It is too soon to know which, if any, access innovations underway in the market will emerge to become large-scale, economically sustainable models to provide access and encourage adoption among underserved men, women, and children in all markets. Most of these models will not succeed, but even one or two successes can help shift the paradigm for serving the hardest-to-reach end users. Even if such disruption never takes place, these innovations can enable deeper understanding of what works in terms of promoting adoption through improved affordability, incentives to adopt, and capabilities.

Creation of an SDG target for accelerated universal access to internet underscores the global commitment to reach the underserved. The next step is for the dynamic constellation of actors with a stake in realizing the SDGs—from governments to industry to the development community—to learn together how best to accelerate universal access in the fastest, most

ACRONYMS TABLE

| ACRONYM | DEFINITION | ACRONYM | DEFINITION |
|---------|--|---------|--|
| AMN | Africa Mobile Networks | MEO | Medium Earth Orbit |
| ARPU | Average revenue per user | MESA | Motorized earth station antennas |
| B2B | Business to Business | MNO | Mobile network operator |
| B2C | Business to Customer | MVNO | Mobile virtual network operator |
| BGAN | Broadband Global Area Network | OPEX | Operating expense |
| CAPEX | Capital expenditure | OPIC | Overseas Private Investment Corporation |
| CONATEL | La Comisión Nacional de Telecomunicaciones | OTT | Over-the-top |
| DFID | UK Department for International Development | ROI | Return on investment |
| DIAL | Digital Impact Alliance | SDG | Sustainable Development Goal |
| DVNO | Data virtual network operator | SIM | Subscriber Identity Module card is a portable memory chip used mostly in mobile phones that operate on the Global System for Mobile communications |
| FIZ | Free Internet Zone | SMS | Short Message Service is a text messaging service component of phone, web, or mobile communication systems |
| GB | Gigabyte | TCO | Total cost of ownership |
| Gbps | Gigabits per second | TV | Television |
| GEO | Geostationary Earth orbit | TVWS | TV white space |
| GSM | Global System for Mobile Communications is an open, digital cellular technology used for transmitting mobile voice and data services | UAV | Unmanned aerial vehicle |
| HAPs | High-altitude platforms | UHV | Ultra-High Frequency, 300 MHz to 3 GHz |
| HRB | Haitian Rural Broadband | UKSA | UK Space Agency |
| HTS | High-throughput satellites | UN | United Nations |
| ICT | Information and communications technology | UNESCO | The United Nations Educational, Scientific and Cultural Organization |
| ICT4D | Information and communications technology for development | USAID | U.S. Agency for International Development |
| IPSP | International Partnership Space Program | USB | Universal Serial Bus is an industry standard developed for cables, connectors and communications protocols |
| ISP | Internet service provider | USF | Universal Service Fund |
| ITU | International Telecommunications Union | VAS | Value added service |
| LEO | Low Earth orbit | VHF | Very-high frequency, 30 MHz to 300 MHz |
| LTE | Standard for wireless communication of high-speed data for mobile phones and data terminals | VOIP | Voice over internet protocol is a methodology and group of technologies for the delivery of voice communications and multimedia sessions over the internet |
| MB | The megabyte is a multiple of the unit byte for digital information | WISP | Wireless internet service providers |
| Mbps | Megabits per second | | |

APPENDIX 1: CATALOGUE OF ACCESS INNOVATIONS

CARIBOU DIGITAL RESEARCH IDENTIFIED 42 EXAMPLES ACCESS INNOVATIONS.

| NAME | DESCRIPTION | FOUNDING DATE |
|-----------------------------------|---|---------------|
| Africa Mobile Network | Africa Mobile Network (AMN) finances, builds and operates solar-powered mobile base stations in remote and unconnected communities. The base stations are then connected to a partner mobile operator's network to provide voice and data services to subscribers in rural areas on a revenue-share basis with zero CAPEX requirement for the mobile operator. | 2013 |
| AirJaldi | AirJaldi provides high-quality broadband connectivity to rural areas at reasonable rates connecting large and small clients from the corporate, civil society and private sectors. AirJaldi provides broadband solutions in rural India using off-the-shelf Wi-Fi equipment. AirJaldi has 9 networks in 5 Indian states covering 24,200 km ² , with over 100,000 users. | 2009 |
| Avanti | Avanti Communications Group provides satellite broadband to over 200 schools in Kenya and is partly funded by U.K. Department for International Development. With the schools providing the anchor customers, Avanti will also sell internet connectivity to the local rural community. | 2014 |
| Botswana Fibre Networks (BoFiNet) | BoFiNet is a wholesale provider of national and international telecommunication infrastructure that does not sell directly to users. BoFiNet will deploy fibre networks and Wi-Fi hotspots in seven strategic locations across Botswana with the Wi-Fi covering close to 600 sites, including hospitals, schools, and hotels. | 2012 |
| Citizen Connect - Namibia | As a part of Microsoft's 4Afrika Initiative, Citizen Connect is a TV white space project in Namibia, and claims to be the world's largest fully operational TV white space deployment. The ultimate plan is to provide a network of broadband internet connectivity across the country. | 2013 |
| CONATEL/ Tigo | The Paraguay regulator La Comisión Nacional de Telecomunicaciones (CONATEL) announced a public-private partnership with the leading mobile operator Tigo to expand mobile broadband coverage. | 2014 |
| Concero Connect | Concero Connect uses a Motorized Earth Station Antennas (MESA systems). These MESA systems are capable of tracking inclined orbit satellites. They propose to offer rural access using these systems, and have developed agent distribution models working with the postal service system in South Africa. | 2013 |
| Dabba | Dabba is a South African company that is pioneering the establishment of microtelco/community GSM networks. It uses wireless technology to provide voice and data services to under-served areas. | 2006 |
| El Paquete | A Cuban media platform based on a web of human data traffickers is a weekly delivery of digital content—everything from American movies to PDFs of Spanish newspapers—that is gathered, organized, and transferred by a human web of runners and dealers to the entire country. | Unknown |
| Endaga | Endaga's answer to bringing cellular access to rural unconnected communities is a community-owned GSM model, a solution they plan to take to hundreds of rural communities around the world. This model focuses on empowering "local network operators," lowering technical barriers to entry of operating networks and creating new entrepreneurial opportunities for individuals in locations outside the reach of existing GSM networks. | 2014 |
| Equity Bank/ Inmarsat | Using Inmarsat's satellite technology, Equity Bank, Kenya's largest retail bank, is able to pilot cached Wi-Fi services through their agent network across Kenya. Wi-Fi-enabled phones give users access to a bespoke platform consisting of both cached and live websites that are text-based or video. | 2015 |

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| NAME | DESCRIPTION | FOUNDING DATE |
|--|---|---------------|
| Ericsson Managed Rural Services | Coverage will be provided via low-power Ericsson cell towers running on solar energy. Ericsson provides rural coverage to mobile operators under a managed service agreement. | 2015 |
| EveryLayer | EveryLayer leverage growing fiber optic availability and low-cost telecom-grade Wi-Fi to connect the last mile with high-speed, fixed-line replacement networks. It has developed a proprietary, cloud-based platform, which makes it simple for ISPs to deploy new networks and services. | 2013 |
| Facebook Express Wi-Fi | Network of cheap Wi-Fi access points that would help residents in remote villages in India to access the internet. In partnership with AirJaldi, which manages the actual installation and operation of the Express Wi-Fi service. | 2015 |
| Facebook/ Eutelsat | A collaboration between Facebook and Eutelsat, a new satellite called AMOS-6, was attempted in 2016 but satellite was exploded at launch. | 2016 |
| Facebook: Connectivity Lab (solar airplanes) | Facebook's Internet.org initiative is developing a high-altitude, long-endurance solar plane. It uses laser communications, and broadcasts a powerful signal covering a city-sized area of territory. The project is part of Facebook's initiative to make affordable internet access possible in remote communities around the world that have no internet infrastructure. | 2014 |
| Fairwaves | Fairwaves have built a technology that lowers the cost of deploying and operating mobile networks in rural regions. They support mobile operators to roll out micro cell towers, using open source software OpenBTS. | 2014 |
| Free Basics by Facebook | Free Basics provides customers with free access to content on their mobile phones in markets where lower income customers cannot afford data plans for internet access. The content includes news, employment, health, education, and other local information. The service sits under Facebook's Internet.org initiative. | 2013 |
| Gigato | Gigato has created a smartphone application where users earn data by using pre-approved applications for a designated period of time. App makers can use the platform to generate app installs and monthly active users and the app makers bear the cost of refunding data to users who install and use their applications. | 2015 |
| Google Free Zone | An initiative in collaboration with mobile operators, whereby the providers waive data charges for access to select Google services, including Search, Gmail, and Google+. | 2012 |
| Google Project Link | Project Link provides fiber backhaul as a neutral wholesaler in Ghana and Uganda, sharing the infrastructure across multiple mobile operators and internet service providers (ISP). | 2013 |
| Google Project Loon | Project Loon is a being developed by Google X with the mission of providing internet access to rural and remote areas. The project uses high-altitude balloons placed in the stratosphere to create an aerial wireless network with up to 4G-LTE speeds. | 2013 |
| Google/Indian Railway | Google's Access & Energy team is bringing connectivity to Indian railway stations in partnership with Indian Railways and RailTel. The network has covered over 100 stations in India | 2016 |
| Guifi.net | Guifi.net is a community-owned mesh network in which volunteers can connect their computers to share an internet connection. Guifi.net is based in Spain and has over 40,000 access points. The network uses best available technologies, radio and fiber, with connections up to 1 Gbps and 10 Gbps internet connections. | 2008 |

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CARIBOU DIGITAL RESEARCH IDENTIFIED 42 EXAMPLES ACCESS INNOVATIONS.

| NAME | DESCRIPTION | FOUNDING DATE |
|---|--|----------------------|
| Inveneo Haiti Connected Cities | Haiti Connected Cities is a collaborative program involving Haitian ISPs, Haitian IT entrepreneurs, and the many organizations—NGOs and otherwise—that will benefit from access to reliable and affordable broadband internet. As of April 2012, the broadband network covers 20% of the Haitian population. | 2011 |
| Jana | Jana is a mobile platform that connects global brands with emerging market consumers through reciprocal advertising. Jana's platform connects brands and consumers, delivering insights to the brand through mobile-based ad campaigns and driving consumer action by incentivizing members with free airtime on their mobile phones. This exchange takes place on the company's opt-in consumer facing platform, mCent. | 2009 |
| LeoSat | High Throughput Satellites (HTS) networked together in a low-earth-orbit constellation. The LeoSat constellation provides worldwide coverage with a high speed, low latency, secured data network. | Planned 2018/2019 |
| Microsoft Mawingu Networks | Microsoft announced the deployment of a pilot project to deliver low-cost, high-speed wireless broadband across Kenya using TV white space. The deployment is called Mawingu Networks, and is the first deployment of solar-powered base stations together with TV white space. | 2013 |
| National Optical Fiber Backbone Project in Colombia | The Colombian government finances a national fiber backbone network to connect 1,078 municipalities to broadband infrastructure. To accomplish this objective, the Colombian government issued a tender with US\$200 million of public funding. | 2010 |
| OneWeb | OneWeb is a satellite start-up, creating a single, pan-global satellite network that promises affordable, high-quality broadband with a global footprint. For emerging markets in South Asia, Africa, Asia and Latin America, this constellation of 648 satellites would provide interlinked, high-speed and 24/7 coverage. | Planned 2019/2020 |
| Outernet | Using a satellite receiver and a tuner, users in Africa, North America, and Europe can access Outernet's content, e.g., local news. Outernet claims to cover 99% of the planet's population. A device they developed, Lighthouse, stores the information it receives from Outernet on its internal drive. Users can connect to the Lighthouse Wi-Fi signal to browse the content. | 2014 |
| poa! Internet | poa! Internet provides a Wi-Fi hotspot solution in Nairobi, where users can pay for access at a lower price, lower latency, and equal or higher speeds as compared to local mobile operators. In addition, users get access to a limited set of internet content for free, at fast speeds from a dedicated cached content server. | 2014 |
| Project Isizwe | Project Isizwe operates as a nonprofit, with the local government financing the CAPEX and OPEX costs of free Wi-Fi hotspots in South Africa. Users can use 500 MB of wider internet access per day, or unlimited access to a cached content portal. Project Isizwe has setup 711 Free Internet Zones (FIZ), and recently connected their one millionth unique user to the network. | 2013 |
| RADWIN's FiberinMotion | FiberinMotion provides free on-board Wi-Fi for city buses in Tshwane, South Africa. Since the project was launched over 200,000 unique users have used the service. | 2014 |
| Rhizomatica | Rhizomatica is a regional telecommunications cooperative that enables communities in Mexico to own and operate GSM networks. They have also been lobbying for regulatory change on behalf of small-scale community networks, arguing for special dispensations from regulators to allow small communities to legally utilize GSM spectrum. | 2009 |

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| NAME | DESCRIPTION | FOUNDING DATE |
|--------------------------|---|---------------|
| Space X | In June 2015 the company asked the federal government for permission to begin testing for a project that aims to build a constellation of 4,000 satellites capable of beaming the internet to the entire globe, including remote regions, which currently do not have internet access. | Planned 2020 |
| Titan Aerospace (Google) | High altitude solar airplanes, which support the effort to blanket the globe in cheap, omnipresent internet connectivity to help bring remote areas online. | Unknown |
| Village Telco | Village Telco sell a Wi-Fi-based mesh network device, Mesh Potato, to allow communities to build a mesh network that allows free local calls, long distance calls, and internet access. | 2008 |
| VillageShare | VillageShare is a content-sharing Facebook application. It allows sharing of content with other users that are in the same area, protecting the bandwidth-limited internet link from content shared between local users. The aim is to increase rural users' use of the internet by reducing negative impacts in the area of content generation and sharing. | 2011 |
| ViRural Africa | ViRural Africa is focused on extending ICT services to underserved rural communities in Africa. ViRural Africa's strategy is to target communities with adult populations greater than 2,000 that have no access to power, no cellular coverage, and no internet access. This approach focuses on providing either a managed service, or a wholesale network service to mobile operators in rural, underserved areas. | 2013 |
| Vodafone Instant Network | Vodafone Instant Network is a micro cell tower developed jointly by Huawei and Vodafone Group. Trained personnel can deploy the system in less than 10 minutes for use in disaster scenarios and relief work. | 2010 |
| Wikipedia Zero | A project by the Wikimedia Foundation to provide Wikipedia free of charge on mobile phones, in partnership with mobile operators, particularly in emerging markets. The objective of the program is to increase access to free knowledge without data-usage cost. | 2012 |
| VAST Networks | VAST Networks is an open-access Wi-Fi network infrastructure provider, delivering carrier-grade Wi-Fi in Southern Africa. They manage, deploy, and develop a Wi-Fi network across 2,200 locations in South Africa, to ensure people enjoy internet connectivity at a much cheaper rate than through other forms of connectivity. | 2014 |

APPENDIX 2: CASE STUDIES OF ACCESS INNOVATIONS

LAST-MILE INNOVATIONS

| | | | | |
|------------------------|-------------------------|------------------|----------------|----------------|
| Endaga (formerly) | Gigato | Mawingu Networks | Project Isizwe | Village Telco |
| Free Basics (Facebook) | ISAT Connection Project | poa! Internet | Rhizomatica | ViRural Africa |

Endaga (acquired by Facebook)

<https://www.endaga.com/>

ACCESS INNOVATION: Microtelco/community GSM

DATE LAUNCHED: 2013

NUMBER OF USERS: 5–10 networks, jointly served approximately 1,000 total end subscribers

MARKETS LAUNCHED IN: Pakistan, Indonesia, Iraq, Philippines

Endaga’s answer to bringing cellular access to rural unconnected communities is a community owned GSM network, a solution to hundreds of rural communities around the world. This model focused on empowering “local network operators,” lowering technical barriers to entry of operating networks and creating new entrepreneurial opportunities for individuals in locations outside the reach of existing GSM networks. Endaga’s customer was the local network operator. In October 2015, Endaga’s leadership team announced it had joined Facebook.

CONDITIONS OF SUCCESS

- Access to existing power and internet backhaul lowers costs.
- Partnership with mobile operators for interconnection.
- Allowances from regulators to use unlicensed spectrum.
- Rural environments where mobile operators struggle to provide affordable network coverage.
- Strong existing community social structures that facilitate the community ownership model.
- Availability of open source software/hardware to build the community network.

TAKEAWAYS

- Evidence of commercial viability of microtelco/community GSM: Endaga’s evidence from existing deployments showed that this model is profitable enough to be sustainable.
- Credit transfer systems could be a key piece of the operational puzzle: Endaga’s credit transfer system—where anyone on the network can move credit between accounts with an SMS—created a distribution system of credit transfer in the community and could be replicated by any business proposing a pre-paid access model.
- Experimentation and unlicensed pilots demonstrate viability: Endaga’s approach was to first build the networks and prove the economic case of these models without a spectrum license. Being able to offer tangible results to commercial and regulatory actors is valuable, and poses a question of whether more of this experimentation should be encouraged.

ORGANIZATION HISTORY AND BACKGROUND

Endaga's approach to offering cellular access emerged from three PhD students at Berkeley. In their research, they noticed several technological shifts, one being software-defined radio.³³ This technology, supplemented with a business model where the community assumes complete ownership of the network and not a mobile operator, was piloted in 2012–2013. Endaga was founded subsequently in 2014 as a for-profit business, receiving early funding (US\$1.2 million) from local venture capitalists (VCs) and angel investors in the San Francisco Bay Area.

The team has since shipped around 5–10 network boxes to a range of markets, including Brazil, Pakistan, and the Philippines serving approximately 1,000 end subscribers. Endaga joined Facebook (September 2015) and the hardware and software components of the company lead to the opensource deployments of OpenCellular and CommunityCallManager, respectively.

OFFERING

The networks provided voice and SMS services not internet access. The community users paid a local network operator, either directly or through agents, using a pre-paid credit system just like most telecom models in the emerging markets. The local network operator was able to set prices and monitor the network through a web-interface engineered by Endaga, which reduces the barrier to network ownership at the local level. Endaga then paid a fee to mobile operators based on the amount of usage between the community network and that of the mobile operator.

ECONOMIC MODEL

The revenue model is based on a fee per communication, which flows along all actors. As an example, a user

might pay 9 cents per SMS to the local operator, who in turn pays Endaga 3 cents, who in turn pay the mobile operator 1 cent (i.e. a 3x markup for each actor along the chain). There isn't a significant markup on the hardware. Endaga achieved US\$500–US\$1,500 in revenue per month per cell site. Costs can be split in terms of CAPEX and OPEX. For the former, Endaga's bill of materials for a unit is US\$2,500 (not at scale production). On the latter, key costs are fixed fees per communication with mobile operators and the support they must offer to their customers. Other key costs include the software development, i.e., new features and maintenance.

OPERATING MODEL

There are four groups of stakeholders Endaga cites for the project: telecoms and regulators at the highest level, Endaga at the next level, the local network owner, then the users. Users can pay the local network owner either directly or through agents, using a pre-paid credit system just like most telecom models in the emerging markets. Operations are split across hardware and software, with the hardware consisting of assembling the bill of materials (including software-defined radio) for each cell site. Endaga's software focused on allowing customers to set prices, manage, and monitor the network. Specific features include: flexible billing system (i.e., set their prices), credit transfer, credit check, number check, number provisioning, and cloud analytics, allowing customers to track and monitor the usage of the network.

PARTNERSHIPS

Partnerships with mobile operators are required to allow interconnection with their networks. Negotiating the business model with mobile operators has proved challenging, and described as the slowest moving part of the model.

33. *Software defined radio (SDR) is a radio communication system where components that have been typically implemented in hardware are instead implemented by means of software on a personal computer or embedded systems.*

APPENDIX 2: CASE STUDIES OF ACCESS INNOVATIONS

Regulators must also be engaged and supportive of the network since they are operating without spectrum licenses.

MARKETING AND DISTRIBUTION

The amount of media interest Endaga received created a greater pipeline of customers than they could serve, typically coming from locals or expats who knew of rural communities demanding connectivity. Customer relationships with Endaga are maintained via a 24/7 support system, and the cloud-based website interface may also act as a future channel through which customer relationships can be maintained.

A distinct set of marketing and distribution considerations apply to the community's users. One of the interesting tools Endaga built was a credit transfer system where anyone on the network can move credit between accounts with an SMS. This was used in Indonesia to create a distribution network of sellers, where a teacher would buy US\$100 of credit from the local operator (the owner of the school) directly onto their phone, and then sell this credit at a small markup to the kiosk owners, who would then sell at another small markup to the community. This method of distribution emerged without Endaga's influence, attributed to the fact that similar distributor/credit systems exist in the countries of operation.

TECHNOLOGY

At its core, Endaga used a CPU that is plugged into a software-defined radio that is then amplified through radio equipment to cover a wider area; the total bill of materials comes to around US\$2,500. All elements were bought "off the shelf" with little focus on optimizing for scale. Users were able to access the Endaga network through basic phones and can access voice and SMS services. For the platform, Endaga designed custom software to handle the management

and operations (billing, credit transfer) and runs the software on the Endaga Cloud. Access to open source technology has been critical for Endaga, helping them reduce CAPEX. Endaga utilized an existing satellite backhaul link and power source from the local school in Indonesia.

REGULATORY CONTEXT

At the early stages of the Indonesian project, the Endaga team made their operation transparent to regulators and mobile operators despite operating without a license to the GSM spectrum. Neither the regulator nor the telecom provider was incentivized to shut down the network as it aligned with their interests to expand access and usage of communications. Nevertheless, as Endaga looks to expand, the biggest barrier they see is regulatory. Current spectrum licensing does not support the entrance of small players and, therefore, there is an unclear regulatory path to scale, which potentially deters future investors. Endaga currently avoids navigating the bureaucracy around USFs for financing and instead opts to pitch directly to commercial investors.

KEY LESSONS

- A software management layer is critical for success: An effective management system (number allocation, billing, network analysis) is necessary to effectively run a microtelco that is operated by a local community-owned network operator.
- Building from established operational telecom practices: Many features of the operational model can be effectively built on existing practices in marketing and distributing mobile services, e.g. airtime distribution via agent networks.
- Most appropriate for rural: This solution is appropriate for locations out of network reach, especially where existing infrastructure assets can be leveraged, e.g., satellite backhaul or power.

Free Basics (Facebook)

<https://info.internet.org/en/story/free-basics-from-internet-org/>

ACCESS INNOVATION: Zero-rating data

DATE LAUNCHED: August 2013

NUMBER OF USERS: 25 million Free Basics users³⁴

MARKETS LAUNCHED IN: 23 Africa; 12 Asia Pacific; 18 Latin America³⁵

Free Basics provides customers with free access to content on their mobile phones in markets where lower income customers cannot afford data plans for internet access. Free Basics forms partnerships with mobile operators who subsidize the cost of data on the assumption that users will migrate to paid data for wider internet usage. The content includes news, employment, health, education, and other local information. The service sits under Facebook's Internet.org initiative.³⁶

CONDITIONS OF SUCCESS

- A market where mobile data costs are prohibitive for lower income populations.
- A strong existing base of smartphone/feature phone users.
- Partnerships with mobile operators who will subsidize the cost of data to users.
- Partnerships with content providers to provide content to the service.

TAKEAWAYS

- Substantial progress has been made: Free Basics has been successful rolling out this model through a range of mobile operator partners across 35 countries,³⁷ and with over 250 content partners on board.³⁸
- Indirect benefits for Facebook are hard to quantify: There are no direct financial returns to Facebook, but there are indirect benefits as internet usage and in parallel Facebook usage increases.
- Navigating the net neutrality debate is critical: Future steps for the Free Basics service are unclear, but adequately answering the net neutrality debate will be critical to further global expansion of the service.

34. <https://info.internet.org/en/impact/>. Accessed January 2017.

35. <https://info.internet.org/en/story/where-weve-launched/>

36. internet.org by facebook. "Connecting the world." Posted at <https://info.internet.org/en/>. Accessed January 2016.

37. Constine, J. "Facebook Confronts The Free Internet Neutrality Dilemma." Posted at <http://techcrunch.com/2015/12/27/gatekeeper-or-stepping-stone/>. Accessed January 2016.

38. Rajan, N. "Facebook renames Internet.org as 'Free Basics', offers open platform for developers." Posted at <http://indianexpress.com/article/technology/tech-news-technology/facebook-opens-up-internet-org-with-new-free-basics-apps/>. Accessed January 2016.

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- Onboarding users to the wider internet through zero-rating is working: In India Facebook claims more than 40 percent of users coming online for the first time with Free Basics pay for access to the full internet within 30 days of joining, generating revenue for partner mobile operators.³⁹

ORGANIZATION HISTORY AND BACKGROUND

The definition of success for Free Basics is to introduce people to the benefits of the internet.⁴⁰ They work in partnership with mobile operators who aim to increase their subscriber base. There is no direct revenue model for Facebook, though there are indirect benefits, including a greater global awareness of the internet and Facebook.

OFFERING

The Free Basics initiative allows app developers, websites, or service providers to place their offering on a platform that enables users free access to a range of basic services in regions where internet access may be unaffordable. The value to those offering services on the platform include: growing audience by providing affordable access to services, scaling social impact, and establishing brands early in the fastest-growing mobile markets. Examples of services included on Free Basics are Babajobs (job matching service), Bikroy (local marketplace), and Maya (mobile health messaging).

ECONOMIC MODEL

Facebook says that Free Basics is designed to promote an internet access model that is free and non-exclusive. Facebook does not require content partners to pay to be included in Free Basics, and does not pay the mobile

operators for the data consumed. Facebook's costs are to develop the platform, develop operator partnerships, and to promote the service to end users.

OPERATING MODEL

Content providers can add their services to Free Basics, which is made as simple as possible. On the mobile operator side, Facebook has built the infrastructure so that it is simple and easy for any operator to integrate into it.

PARTNERSHIPS

Free Basics is open to any developer and any application that meets basic technical requirements.⁴¹ Free Basics is not exclusive to any operator, and Free Basics is willing to work with any operator who wants to provide free basic services.

MARKETING AND DISTRIBUTION

Free Basics is marketed by both Facebook and by ad campaigns from participating mobile operators. Advertising for Free Basics is across a variety of demographics, including rural areas where many people are not yet online.

TECHNOLOGY

Free Basics is open to any developer and any application. Services are compatible with Free Basics if they meet two criteria: (1) they are data-efficient (e.g., services that use VOIP, video, file transfer, or photos larger than 200 KB are not compatible), and (2) they meet the technical specifications outlined over areas including: mobile compatibility, which ensures the service is compatible with feature phones, and JavaScript dependency, meaning services must be able to function

39. Internet.org by Facebook. "Free Basics: Myths and Facts." Posted at <https://info.internet.org/en/2015/11/19/internet-org-myths-and-facts/>. Accessed January 2016.

40. Internet.org by Facebook. "Free Basics by Facebook." Posted at <https://info.internet.org/en/story/free-basics-from-internet-org/>. Accessed January 2016.

41. Facebook for developers. "Free Basics Platform." Posted at <https://developers.facebook.com/docs/internet-org>. Accessed January 2016.

normally in the absence of JavaScript (important for lower end mobile devices). Users can access the platform via smartphones or feature phones.

REGULATORY CONTEXT

The greatest concerns and regulatory barriers levied against Free Basics stem from the net neutrality debate. India has been an epicenter for this debate, with the Indian regulator blocking the service in February 2016.⁴² Net neutrality activists argue Free Basics splits the internet.⁴³ On the one hand users get a whole internet where they have to pay data charges. On the other they get a free, stripped-down internet that promotes a few websites, thereby giving them advantage over competition and creating monopolies. A key question is whether users are moving from Free Basics onto the wider, open internet. Facebook claims in India 40 percent of people who use Free Basics are paying for data and access the internet outside of the free services within 30 days of coming online for the first time.⁴⁴

KEY LESSONS

- Need for a transparent process to select content providers: For those that adopt a ‘walled garden’ model, a transparent approach to selecting partnerships with content providers will be required to avoid criticisms of monopolizing the experience of the “open internet.”
- Net neutrality will be an ongoing policy concern for zero-rated/sponsored data models: These models have tended to provide access to a limited set of free content, a “walled garden.” The promotion of such content is a controversial issue because it shows favoritism and free access to a subset of internet content that creates advantage over competing services.

- Evolution to a smartphone user base: The smartphone zero-rated experience outstrips that of a feature phone, creating a stronger value proposition. The number of users who have smartphone access but limited data access is also rapidly rising. For these reasons, zero-rated models will likely increasingly target a smartphone user base.

Note: Case study completed from secondary sources, since the Free Basics team was unable to be interviewed.

42. BBC News. “India blocks Zuckerberg’s free net app.” Posted at <http://www.bbc.co.uk/news/technology-35522899>. Accessed February 2016.

43. Vij, S. “Why is Facebook so eager to woo India.” Posted at <http://www.aljazeera.com/indepth/features/2015/10/151028092023463.html>. Accessed January 2016.

44. Internet.org by Facebook. “Free Basics: Myths and Facts.” Posted at <https://info.internet.org/en/2015/11/19/internet-org-myths-and-facts/>. Accessed January 2016.

Gigato

<http://www.gigato.co/>

ACCESS INNOVATION: Sponsored data

DATE LAUNCHED: July 2015

NUMBER OF USERS: 250,000 users

MARKETS LAUNCHED IN: India

Gigato has created a smartphone application where users earn data by using sponsored applications. App developers can use the platform to generate app installs. Monthly active users and the app developers bear the cost of refunding data to users who use their sponsored apps. This model helps address the demand-side, affordability barriers to access, providing internet access to underserved segments where existing data costs are prohibitive or restrictive for lower income user segments. Gigato's customers are the app developers.

CONDITIONS OF SUCCESS

- A market where mobile data costs are prohibitive for lower income user segments.
- Strong existing base of smartphone users.
- A burgeoning app ecosystem where discovery and user churn are significant challenges.
- Partnerships with app developers who subsidize the cost of data.

TAKEAWAYS

- Gigato focuses on the Indian market: Focusing efforts on one market allows Gigato to maximize the number of apps from Indian app developers they have on their system. In parallel, the more users they have the more attractive their platform becomes to app developers.
- Behavioral success metrics, “leave data turned on”: Part of Gigato's mission is to get “Indian users to leave their data turned on.” Without this, Indian app consumers are unlikely to behave like app consumers in developed markets, making it harder to translate app business cases to the Indian market.
- A Data Virtual Network Operator concept: Gigato sees itself as potentially becoming the first DVNO (data virtual network provider) in India buying wholesale data from aggregators, along the same lines as MVNOs (mobile virtual network providers).

ORGANIZATION HISTORY AND BACKGROUND

Gigato's team came together in 2014, and became interested in the problem of smartphone data during their visits to India where they encountered issues topping up SIM cards. To address this, they initially created a solution that paid users with data, for ad impressions served on dormant screens on their phones, e.g., locked screens. The product eventually evolved away from general advertising, to one in which users earn data by using sponsored applications. Gigato launched its app on July 30, 2015, and within 30 days, had 100,000 users sign up. To date, they have received over 250,000 sign ups.

OFFERING

Gigato is using its technology and concentrating on being able to be work on any GSM network. In India, prepaid mobile users represent around 95 percent of the market. Gigato conducted studies and found that these users were rationing data, topping up miniscule amounts on their phones for fear of hidden data costs. Gigato's platform allows these users to earn data "recharges" by using sponsored apps, reducing data costs and enhancing the smartphone experience. App developers struggle to generate new installs and monthly active users, since they tend to pay prohibitively high costs to other platforms such as Facebook and mobile ad networks to market their app. With Gigato's model, app publishers bear the costs of refunding data to users who install and use their applications.

ECONOMIC MODEL

Key costs for Gigato span two areas: wholesale data costs per MB, and the team costs for app development and sales. Gigato has three revenue streams: first, charging app publishers per MB consumed by users, along with a small license fee; second, revenue from

co-branding promotions between Gigato and app developers, and third, enterprise sales for larger apps, currently the largest revenue source. Gigato is seed funded and currently raising their series A, targeting US\$5–US\$10 million. Gigato is mainly targeting Indian VCs, since this group understands the market better than VCs from other regions.

OPERATING MODEL

Software development operations are split between ongoing platform development and white label app development. Sales and marketing encompasses generating new sign-ups from app developers onto Gigato's platform, and co-branding promotions between Gigato and app developers. Key metrics for success include driving growth and retention of both customers (app-publishers) and users (pre-paid smartphone users). Like many app-based models, the growth and activity of Gigato's installed smartphone base is what attracts app developers and investors to their model.

PARTNERSHIPS

Gigato initially explored mobile operator partnerships but discovered that mobile operators would not be willing to work with one another. Instead, Gigato partnered with companies that purchase data from all the major mobile operators, which allows Gigato to bulk buy data across all networks, enabling interoperability.

MARKETING AND DISTRIBUTION

There is a major barrier around app discovery in India for both Gigato and its app developer customers. The Google Play store only facilitates easy discovery of a tiny fraction of apps on the market. In addition, alternative app stores and the phenomenon of user sideloading can make it hard to monitor and drive new installs. Trying to market products is also challenging, because India is described as a "very noisy market," and one that relies heavily on word of mouth. In addition, it

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is challenging to get users to keep applications on their phone as users often install and uninstall apps to make room for more current apps.

Technology: Gigato's product is a software-based platform, delivered entirely over existing GSM networks. Gigato works over all Indian mobile operator networks. It is important to note that Gigato's app does not register the data used by customers when accessing applications through Wi-Fi networks. Gigato's application is currently delivered on Android phones only (Android 4.1 and above), and is a 4 MB download.

REGULATORY CONTEXT

Gigato's business model does not conflict with current regulations, but might be misunderstood as a violation of net neutrality like zero-rating. As opposed to zero-rated models, Gigato's data recharge approach ensures that users first access the application as they normally would, and then allows users to use reimbursed data for any service. In addition, Gigato do not track what websites these users are using the reimbursed data for. As a result, they have been cited⁴⁵ as an example of how to sponsor data in a way that complies with net neutrality. Gigato does not allow any "category exclusives" within the app, and so app publishers are made discoverable in an equitable manner (e.g., through randomizing order apps are shown in).

KEY LESSONS

- Sponsored data models can thrive in burgeoning app eco-systems: App developers in emerging markets struggle with user acquisition and retention, making sponsored data models an effective way to encourage greater app usage by customers.
- Sponsored data receives less net neutrality critique: Zero-rating and sponsored data are different business models that have different implications for net neutrality. Those concerned with net neutrality should consider business models like Gigato.

45. Save the Internet. "STI Statement on Mark Zuckerberg's townhall at IIT Delhi." Posted at <http://blog.savetheinternet.in/response-to-facebook-townhall/>. Accessed January 2016.

ISAT Connection Project (Equity Bank and Inmarsat)

ACCESS INNOVATION: GEO backhaul, commercial and cached Wi-Fi

DATE LAUNCHED: 2015

NUMBER OF USERS: 200 agents, estimated 5,000 households (for pilot stage)

MARKETS LAUNCHED IN: Kenya

Using Inmarsat's satellite technology, Equity Bank, Kenya's largest retail bank, is able to pilot cached Wi-Fi services through their agent network across Kenya. Customers use Wi-Fi-enabled phones to access a bespoke platform consisting of both cached and live websites that are text based or video. The cached content is provided to customers for free at high speeds because the content is stored in a local cache. Equity Bank/Inmarsat's customers are the users.

CONDITIONS OF SUCCESS

- Use of a pre-existing, sizeable agent network (i.e., bank agents) for sales and distribution.
- Rural environments where mobile operators struggle to provide affordable network coverage.
- High adoption of Wi-Fi-enabled feature phones and smartphones.

TAKEAWAYS

- Satellite companies are incentivized to explore "last mile" access: Given that satellite is the most ubiquitous form of backhaul access, major satellite companies have an interest in understanding the different business models that can provide access while generating a profit.
- Cached content systems are demonstrating value: Cached content systems provide free access to a limited set of digital content for free. Users are consuming content regularly, though some content refresh issues must be considered, e.g., some younger users had already watched all videos from their favorite cached shows and had since stopped using the hotspot.

- Satellite best deployed in areas with lowest likelihood of competing access innovations: The relatively higher cost and lower speed of satellite means it is displaceable by lower cost, faster access innovations, but is indispensable in rural areas where fiber does not exist and cell towers are too expensive.

ORGANIZATION HISTORY AND BACKGROUND

Inmarsat is a provider of satellite connectivity, with 12 satellites currently in orbit that provide connectivity across every continent. Equity Bank is a financial services provider and licensed commercial bank headquartered in Nairobi, Kenya. The organizations have partnered to provide satellite connectivity to 200 rural Equity Bank agent locations across Kenya.

OFFERING

Equity Bank agents provide a Wi-Fi hotspot using geostationary satellite backhaul using a Broadband Global Area Network (BGAN) terminal. Agents and consumers use Wi-Fi-enabled phones to access a

APPENDIX 2: CASE STUDIES OF ACCESS INNOVATIONS

bespoke platform consisting of both cached and live websites that are text based or video, and includes topics on agriculture, entrepreneurship, education, health, entertainment, and other Equity Bank services.

The cached content is provided to customers for free at high speeds because the content is stored locally. Equity Bank agents use the Wi-Fi as a means to drive greater footfall in their stores, while Equity Bank benefits from an increase in the number of bank transactions at these stores.

ECONOMIC MODEL

The CAPEX costs per location are US\$2,000–US\$4,000, which includes assembly and installation, training and starter phone/tablet costs. Many agents reported an increase of US\$1–US\$2 per month in power costs to their business as a result of the hotspot installation. The model is still in pilot stage, but some users have expressed willingness to pay for the right content. Other revenue sources such as cross listing other Equity Bank services or pursuing third party advertising are being explored.

The funding for the work stems from a grant from the U.K. Space Agency (UKSA), as part of a £32 million, International Partnerships Space Program (IPSP), to open up opportunities for the U.K. space sector to work with international partners to develop satellite technology and applications in emerging economies.

OPERATING MODEL

The pilot started by selecting 200 agents from an existing agent network of over 17,000 agents. These agents have reported an increase in foot traffic, citing between 10 and 20 more customers per day, with some reporting an increase of nearly 50. Data consumption varies drastically across the pilot, with the top 10 sites accounting for almost a quarter of total data consumption; 4 out of the top 10 sites are

schools. As the pilot continues, Equity Bank is exploring ways to engage other merchant agent shops, such as Agrovets, which are the local agricultural hubs, providing information for farmers while functioning as a dealmaker between farmers and the buyers.

PARTNERSHIPS

In addition to Equity Bank and Inmarsat, a range of organizations has assisted with the pilot. These include Caribou Digital, an advisory services company focused on building emerging market digital economies, Dalberg, a strategic advisory firm dedicated to global development, and The Satellite Applications Catapult, a not-for-profit innovation and technology company created to drive economic growth through the development of satellite applications. Other supplier partners on the project include BRCK, a company based in Nairobi that builds self-powered, mobile Wi-Fi devices.

MARKETING AND DISTRIBUTION

The network of 200 Equity Bank agents drives the sales and distribution to users. After selection, the agents must be on-boarded and trained to use the Wi-Fi devices. On the customer awareness side, agents indicate a desire for increased marketing support. The majority of customers discover the hotspot through automatic notifications when their device detects the Wi-Fi signal, while the agent informs the rest.

TECHNOLOGY

The project utilizes Inmarsat's BGAN Link to connect with their satellites at each of the access points. BGAN Link operates over the Inmarsat-4 network, which has ubiquitous satellite coverage. Terminals have low power consumption and can run off mains, batteries or solar panels. In addition, the pilot uses BRCK mobile Wi-Fi devices to provide Wi-Fi coverage to users.

The BRCK also stores the cached content portal ‘My Life’, in addition to providing access to 100 websites. A distinct content portal targets schools—“Wings to Fly”—which prioritizes education and learning content.

REGULATORY CONTEXT

There are no major regulatory hurdles to the model. Satellite backhaul is already commercially available, and Wi-Fi utilizes unlicensed spectrum bands.

KEY LESSONS

- The willingness to pay for access in rural settings: Users in the pilot expressed willingness to pay, given the right content. Personal data consumption habits vary drastically, however, with user estimates ranging from US\$0.15–US\$1.50 per day for data.
- Satellite in combination with cached Wi-Fi: Provides an attractive balance of ubiquitous coverage for rural regions, while the free access to cached content addresses affordability constraints.

Mawingu Networks

<http://mawingunetworks.com/>

ACCESS INNOVATION: Rural ISP (using TV white space and microwave)

DATE LAUNCHED: 2013

NUMBER OF USERS: Unknown

MARKETS LAUNCHED IN: Kenya⁴⁶

Microsoft announced the deployment of a pilot project to deliver low-cost, high-speed wireless broadband across Kenya in the TV white space band. Developed by Microsoft Research, Mawingu Networks is the first deployment of solar-powered, TV white space technology to deliver high-speed (up to 20 Mbps)⁴⁷ internet access to rural areas.⁴⁸ The signal from TV white space can travel four times the distance of regular Wi-Fi, and bend around walls and physical barriers better than Wi-Fi. Mawingu Networks's customers are both local businesses and institutions and users in the community.

CONDITIONS OF SUCCESS

- Regulatory approval for use of TV white space spectrum in trial and commercial deployments.
- Rural environments where mobile operators struggle to provide affordable network coverage.
- High adoption of Wi-Fi-enabled feature phones and smartphones.

TAKEAWAYS

- The promise of TV white space is far reaching: White space spectrum can be used, Microsoft claims, to provide wireless, broadband access to the 80 percent of Kenyans who do not have access to the internet.⁴⁹
- Regulatory change for TV white space has been slow: Microsoft's ambition is to convince regulators

to develop legal frameworks that support broader commercial deployment of the technology. As yet, the regulator has not allowed Microsoft to expand its pilot beyond its current scope.

- Strong private sector knowledge base: Commercial players, notably Microsoft, have led the funding and research into pilot TV white space deployments. These players will be key in providing evidence to support the commercial TV white space case.

ORGANIZATION HISTORY AND BACKGROUND

Mawingu Networks is the first of six TV white space pilots Microsoft has deployed in Africa in collaboration with partners. Microsoft's goal is to demonstrate the commercial and technical viability of TV white space so regulators are convinced of the value in the market.

46. This is one of a larger set of Microsoft pilots spanning Botswana (2015), Ghana (2014), Namibia (2014), Philippines (2014), South Africa (2013), Tanzania (2013), and Kenya (2013).

47. Mawingu Networks. "Our Technology." Posted at: <http://www.mawingunetworks.com/our-technology.html>. Accessed January 2016.

48. Juma, V. "Microsoft's rural Kenya Internet bid gets Sh400m." Posted at <http://www.businessdailyafrica.com/Corporate-News/Microsoft-s-rural-Kenya-Internet-bid-gets-Sh400m/-/539550/2810050/-/8f7p6jz/-/index.html>. Accessed January 2016.

49. Garnett, P. "Delivering low-cost, solar-powered Internet access to rural Kenya." Posted at <http://blogs.microsoft.com/on-the-issues/2015/06/09/delivering-low-cost-solar-powered-internet-access-to-rural-kenya/>. Accessed January 2016.

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Microsoft's work on this with the Kenyan government dates back to 2011, where they first showcased the use of TV white space technology. Mawingu Networks established its initial funding from Microsoft's 4Afrika initiative, the U.S. Agency for International Development (USAID), investment from angel investor Jim Forster, and Paul G. Allen's Vulcan, Inc. Ultimately, the approach appealed to the Overseas Private Investment Corporation (OPIC), which committed to providing a US\$4.1 million loan in September 2016 to enable commercial expansion of Mawingu Networks's model further across Kenya.⁵⁰

OFFERING

The Mawingu Networks pilot project began in Nanyuki, around 200km north of Nairobi in Kenya. It connects eight customer locations, five schools, the Laikipia County government office, Laikipia Public Library, Red Cross, and the Burguret Dispensary health care clinic. The value proposition for users focuses on avoiding time-consuming trips of many kilometers, often traveled on foot, to expensive internet cafes for checking emails, researching job opportunities, and looking for other information. Device charging is also part of the value proposition to these users, who would otherwise travel large distances to recharge their mobile devices. For businesses or institutions like schools, the value is faster and cheaper internet access than would otherwise be available. Currently Mawingu Networks maintains merchants in 28 different townships.⁵¹

ECONOMIC MODEL

Customers are charged for access on a weekly or monthly basis. Mawingu Networks charges roughly US\$0.50 for 24 hours (300 MB cap), US\$1 per

week (500 MB cap), US\$3 for one month (2 GB), or US\$10 for a three-month package (8 GB), and device charging.⁵² After the data thresholds are reached, connectivity throughput is slowed. No public information is available on the costs of the network.

OPERATING MODEL

The pilot has sought a diverse range of locations, including schools, a health clinic, local government, and the Red Cross in Nanyuki.⁵³ Microsoft has provided Windows 8 tablets, Windows 8 applications, and Microsoft Office 365. Another partner, Indigo, has provided computer labs and instruction to each school and library, working with community leaders and local companies to identify the most beneficial services and applications for each location, including agriculture and education services. Commercial details of the pilot are not publically available, though some social impact results have been shared, for example school students improving their scores in the Kenya National Exam due to accessing online content and standardized test preparation materials.

PARTNERSHIPS

A key partnership for the project is the Kenyan Ministry of Information and Communications which provides regulatory allowances for the pilot to take place.

MARKETING AND DISTRIBUTION

Mawingu Networks is working across a range of locations where individuals are finding out about the service in different ways. In schools, students are introduced to the service as part of an organized curriculum. In other instances, Mawingu Networks agents, selling low-cost internet access and device charging to their rural

50. <https://www.opic.gov/press-releases/2016/opic-and-microsoft-commit-support-wireless-internet-expansion-kenya>

51. <http://mawingunetworks.com/merchants/>

52. Mawingu Networks. "Our Technology." Posted at: <http://www.mawingunetworks.com/our-technology.html>. Accessed January 2016.

53. Microsoft Research. "Pilots and Demonstrations." Posted at <http://research.microsoft.com/en-us/projects/spectrum/pilots.aspx>. Accessed December 2015.

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communities, have launched community hubs that offer access.

TECHNOLOGY

TV white space involves TV frequencies assigned to broadcasters that are not used locally. Mawingu Networks uses low-cost wireless technology and solar power to build internet networks in rural areas, where customers use Wi-Fi to connect. The service delivers bandwidth speeds of up to 15 Mbps. Microsoft claims the latency is similar to a typical broadband deployment, and believes they can achieve a range of at least 10km around a transmitter site. These technologies can support both high-bandwidth and low-latency applications, such as video streaming and Skype video conferencing.

REGULATORY CONTEXT

The tests in Kenya are meant to highlight the viability of TV white space to convince African countries to accelerate legislation that would enable TV white space technology to provide internet access.⁵⁴ Conditions to the Kenyan pilot included operation in the frequency bands 470 MHz to 694 MHz for a limited number of geographically and time confined trial networks.⁵⁵ As yet, the regulator has not allowed for the commercial use of the TV white space requisite for the pilot to exceed its current scope.

KEY LESSONS

- Combination of TV white space spectrum alongside Wi-Fi: Mawingu Networks claims that by using TV white space spectrum, they demonstrated that three base stations cover areas of almost 235 km².⁵⁶
- Capable local Kenyan systems integrators: Mawingu Networks say that local integrators are very capable of deploying and maintaining the software and hardware with minimal training. This is a promising result for other providers looking to roll out hardware in rural areas.
- Cloud based management: The TV white space trial in Kenya has successfully managed deployments remotely via the cloud, demonstrating that remote management of all network components is possible in rural areas.

Note: Case study completed from secondary sources as Mawingu Networks team unable to be interviewed.

54. Wanjiku, R. "Google, Microsoft pilot TV white space project in Kenya and South Africa." Posted at <http://www.pcworld.com/article/2036390/google-microsoft-pilot-tv-white-space-projects-in-kenya-and-south-africa.html>. Accessed January 2016.

55. Haji, M. "Licensing of TV White Space Networks in Kenya." Posted at <http://www.itu.int/en/ITU-R/study-groups/workshops/RWP1B-SMWSCRS-14/Presentations/KEN%20-%20Licensing%20of%20TV%20White%20Space%20Networks%20in%20Kenya.pdf>. Accessed January 2016.

56. Microsoft et al. "Rural Broadband Trials – Laikipia County Kenya – For the Communications Authority of Kenya." Posted at http://www.dynamicspectrumalliance.org/assets/TVWS_Report_for_Kenya_final_final_24_Aug.pdf. Accessed January 2016.

poa! Internet

<http://poainternet.net>

ACCESS INNOVATION: Paid commercial Wi-Fi

DATE LAUNCHED: 2015

NUMBER OF USERS: Targeting connecting over 10m customers over the next 5 years

MARKETS LAUNCHED IN: Kenya

poa! Internet provides a Wi-Fi service in Nairobi, where users can get high speed Internet access at a far lower price than local mobile operators. In addition, users get free access to a limited set of digital content served from a dedicated cached content server. Poa! Internet's customers are users in Nairobi.

CONDITIONS OF SUCCESS

- A strong existing base and increasing uptake of Wi-Fi enabled smartphone users
- Prohibitively expensive internet services from mobile operators
- Access to distribution channels to promote and distribute the service effectively
- Urban environments with a high population density of potential users

TAKEAWAYS

- Caching is a cost-effective content delivery model: One piece of downloaded content can be distributed from a cache to many users with virtually no incremental cost on the network, making it economically feasible to deliver rich media content, e.g. video, to a large volume of users at very low price points.
- The low CAPEX cost for access points is striking: At a few hundred dollars per access point they are an order of magnitude lower than some of the microtelco/community GSM networks (though it should be noted that access points cover a smaller area).
- Regulatory challenges to Wi-Fi are minimal: Wi-Fi uses unlicensed spectrum so avoiding the costly license fees associated with acquiring spectrum, lowering barriers to entry.
- Widespread availability of Wi-Fi devices ensures viability of Wi-Fi networks: Significant adoption of Wi-Fi-enabled devices enables poa! Internet to deploy a low-cost, Wi-Fi based network.

ORGANIZATION HISTORY AND BACKGROUND

With previous experience working at Fon, the world's largest Wi-Fi network, Andy Halsall and poa! Internet's founding team saw the opportunity to pioneer building operator-grade networks using primarily Wi-Fi based technologies. The ability to build networks at a much lower price point, enabling delivery of internet access at a cost cheaper than traditional cellular networks could offer, was the starting point for poa! Internet. poa! Internet's team is currently 25 full-time people, many with emerging markets telecom backgrounds or hired from the communities that poa! Internet serves. The business was originally founded in the United Kingdom, but has since moved to Nairobi.

OFFERING

The team found that users in urban environments were significantly limited by the terms of use and high costs of data bundles from mobile operators. To solve this problem, poa! Internet uses a low-cost Wi-Fi network to bring down the price of data, and a community sales and distribution model to ensure effective promotion. poa! Internet also competitively differentiates its service by providing a quota of free access to content stored on a cache in the network. poa! Internet targets customers between the ages of 18 and 25 who live in low-income urban areas and are smartphone users. These users understand the "personal business case" for being online and, typically own a smartphone but cannot afford to use data because of expensive data bundles. poa! Internet identified this demographic as potential product evangelists who could convince others to come online.

ECONOMIC MODEL

Revenue is driven from the user on a per-MB basis, split across: (1) paid for, open internet access and (2) free

access to cached content. Costs are split across CAPEX with the Wi-Fi access points, installation, and backhaul costing a few hundred dollars per site, and OPEX for distribution, network maintenance, and marketing. Customers can pay via mobile money or a network of local agents. The agents are compensated on a system analogous to the mobile airtime distribution system, i.e., vendors get a percentage of the airtime sale. Airtime wholesalers are incentivized with discounts at larger volumes.

OPERATING MODEL

poa! Internet develops the access network technology, the proprietary local content caching system and builds relationships with local ISPs to manage the backhaul. The team targets localities in which the model can be implemented, adapting the business model to work with the communities to promote the service and protect network assets. The team also forms relationships with vendors to get the optimum cost for each access point.

PARTNERSHIPS

poa! Internet's partnerships stretch across internet backhaul, tower space, and sales and distribution. In Kenya, they are partnering with an ISP that provides internet backhaul in addition to data center space. On the tower space side poa! Internet is partnering with those who own and maintain community locations (e.g., churches, schools), in addition to "cybers" who own local internet café outlets. These local community members are engaged to deploy and maintain the network. Finally, on the sales and distribution, agents are engaged to sell airtime to the network and hires from the local community are used to sell and promote the service to customers. poa! Internet notes the importance of building relationships the local community, as this helps build the credibility of the service.

MARKETING AND DISTRIBUTION

APPENDIX 2: CASE STUDIES OF ACCESS INNOVATIONS

poa! Internet is piloting a viral marketing effort where a successful recommendation will reward both “recommender” and “recommendee” with free internet access. From here users can pay for access to poa! Internet’s network in two ways: via mobile money or using cash. The latter includes a network of around 150 agents (including the cybers, other shops, and existing airtime vendors). The model is a pre-paid system, with a central wholesaler (e.g., serving 50 stores). Signing up for the service is very simple, requiring a few SMS exchanges with a free number.

Cybers typically consist of half a dozen PCs linked to a GSM modem, selling access to the internet, with their principal revenue coming from up selling other services (e.g., printing and laminating, training on use of Facebook). In exchange for housing a Wi-Fi access point and providing customer service to poa! Internet’s customers the cybers receive a certain level of free internet access, which offsets their existing internet connection cost. They have a shared interest in bringing more people online and creating a greater footfall of customers through their outlets. In addition, poa! Internet hosts some of its Wi-Fi access points on schools, health centers and other community organizations in exchange for free internet access. poa! Internet’s approach with a focus on local community involvement is believed to be key in reducing potential theft of Wi-Fi hotspot equipment.

TECHNOLOGY

Poa! Internet has built out around 75 Wi-Fi access points in the Kibera slum in Nairobi. Each access point covers a radius of up to 250m. These access points are connected to wireless backhaul network operated by poa! Internet and eventually into a fiber connection. A data center in Nairobi then handles the billing, Operations Support Systems (OSS), and so on. Although the current focus is densely populated areas such as Nairobi, poa! Internet intends to adapt the model to peri-urban or rural communities.

Each one of the access points is made mostly from readily available components with a few custom poa! Internet features, costing a few hundred dollars. This bill of materials consists of two radios and two antennas, a car battery, solar cell, and power controller. The solar and battery combination remove the need for diesel or grid electricity. The service delivers high speed internet suitable for video streaming and other hand bandwidth applications. The content caching system is placed on servers in the network and provides a “walled garden of content”. Through the cache, poa! Internet drastically reduces the incremental costs of delivering content across the Wi-Fi network, making it far more economically viable to deliver rich content when compared to accessing the same over the wider internet.

REGULATORY CONTEXT

poa! Internet is regulated by the Communication Authority of Kenya and possesses three licenses: A Network Facility Provider license allowing them to physically build the network; a Content Service Provider license allowing them to provide content; and an Application Service Provider license allowing them to sell internet access. Kenya is regarded by poa! Internet as relatively strong from a regulatory perspective, with a structured and transparent process for all applications. Operating within the unlicensed Wi-Fi bands is seen

as much less of a challenge as compared with GSM spectrum, since the associated licenses in the former case are in the thousands of dollars whereas the latter are many orders of magnitude higher in cost.

KEY LESSONS

- Wi-Fi is a credible technology for providing mass-market internet delivery. The low costs of internet technology and its wide spread adoption in smartphones allows for a far more cost effective delivery of internet services than traditional technologies such as cellular.
- Cached Wi-Fi is a critical gateway for users: The cache allows users to have access to internet content for free, which translates into a richer user experience that can drive subsequent interest in paying for access to the wider internet. Other providers should consider the value of offering rich content and media via a cache as a gateway to encourage use.
- Walled garden objections must be considered: The amount of content available via the cached content system is substantially less than the wider internet, meaning the curation of content and means by which users are encouraged/discouraged from exploring the wider internet must be considered by anyone offering a cached content model. A walled garden can be used drop barriers to getting online adoption and does not necessarily lead to limiting customers access to the wider internet.

Project Isizwe

<http://www.projectisizwe.org/>

ACCESS INNOVATION: Free public Wi-Fi and cached Wi-Fi

DATE LAUNCHED: 2013

NUMBER OF USERS: 1,050 Wi-Fi hotspots, 2.7 million end users

MARKETS LAUNCHED IN: South Africa

Project Isizwe operates as a nonprofit, with the local government financing the CAPEX and OPEX costs of free Wi-Fi hotspots in South Africa. Customers can use 500 MB of wider internet access per day, or unlimited access to a cached content portal. Project Isizwe has set up 1,050 Free Internet Zones (FIZ), and have connected 2.7 unique users to the network. Project Isizwe's customers are the users.

CONDITIONS OF SUCCESS

- Public funding to support citizen internet access.
- Access to low cost, fiber backhaul.
- Densely populated urban/peri-urban environments as well as rural deployments.
- High adoption of Wi-Fi-enabled feature phones and smartphones.

TAKEAWAYS

- The non-profit model: Project Isizwe operates as a nonprofit, making it attractive to financing by country governments and international donors/foundations.
- Viable in urban/peri-urban environments: The free access model is more cost effective to deploy in urban/peri-urban areas that have a higher population density and also likelihood of fiber backhaul.

ORGANIZATION HISTORY AND BACKGROUND

Project Isizwe believes the best way to reduce digital inequality is for the government to treat the internet

like a public utility. Its nonprofit structure allows them to operate without the need for profit margins. Its team of 25 is split between offices in Pretoria and Stellenbosch, South Africa. Project Isizwe started in 2013 when the first CEO, Alan Knott-Craig, Jr., was running Mxit, and made a deal with the Stellenbosch municipality to offer free Wi-Fi in public spaces. Mxit would “donate” the bandwidth and Wi-Fi equipment while the municipality would provide the electricity and the community infrastructure to house the Wi-Fi equipment.

Today Project Isizwe has setup 1,050 FIZ sites and has connected their 2.7 millionth unique user to the network. The city of Tshwane is their flagship project, though Project Isizwe also has 10–15 pilot projects around South Africa.

OFFERING

Project Isizwe's customers include local governments (i.e., Tshwane municipality), specific government departments (e.g., Department of Higher Education, or Department of Agriculture), NGOs, and privately funded initiatives (e.g., local community centers). Also

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users can access the content portal via their Wi-Fi-enabled device, gaining unlimited access to a cached content portal, and 500MB of wider internet access per day.

ECONOMIC MODEL

The two main costs of this model are bandwidth and hardware. CAPEX of access points vary by geography: urban FIZ sites are around R90,000 (~US\$6,000) per site, peri-urban costs R120,000 (~US\$9,000) per site, while rural FIZ sites cost around R150,000 Rand (US\$11,000). Project Isizwe estimates that for the same service, CAPEX is cheaper on satellite by 50% but OPEX cost increases by a factor of 3. Local government funds the OPEX and CAPEX. To help cover OPEX costs, Project Isizwe is exploring selling value-added services such as Wi-Fi TV (external funding provided by Omidyar Network) to customers.

OPERATING MODEL

The Project Isizwe team performs four core functions: conducts proof of concept pilots, manages deployment of new FIZ points, monitors the impact of sites to report to customers on engagement, and develops new content. Project Isizwe employs local ISPs to install and maintain FIZ sites, providing employment opportunities in the local economy while keeping Project Isizwe's core team to a minimum. On the content side, Project Isizwe has developed Wi-Fi TV on their content portal, a video on-demand service that includes short snippets developed by young citizen journalists in their communities. Project Isizwe is exploring other value-added services, such as a Wi-Fi voice calling service, a basic chat service, and a "Wi-Fi drive-in" service, where users can stream movies with unlimited access in certain areas at certain times.

PARTNERSHIPS

Project Isizwe negotiated partnerships with commercial companies to provide equipment and backhaul at nonprofit reduced rates, local ISP's to deploy and maintain network access points, and content providers to offer content to its portal. Project Isizwe works with local governments to identify municipal buildings as future FIZ sites.

MARKETING AND DISTRIBUTION

For marketing, Project Isizwe uses its free Wi-Fi Champions Program to promote the Wi-Fi access to young individuals, manage the free Wi-Fi in their communities, and capture data about the site usage, e.g., sharing stories of users on whom the free Wi-Fi has had an impact.

TECHNOLOGY

Project Isizwe's FIZ sites each cover a 150m square area (e.g., public park, school). Eighty-five percent of the daily user traffic is through mobile phones. The key difference between urban and rural locations is backhaul availability, with fiber access in urban locations lowering costs, while more expensive satellite backhaul is used in rural locations. Users access the service predominantly using smartphones; each user is allocated 500 MB per day (15 GB per month) free, at download speeds of 15 Mbps. The FIZ service blocks a few sites, e.g., gambling and pornography, but otherwise offers open internet access. Project Isizwe's content portal allows for unlimited free access, while allowing content partners to offer digital content.

REGULATORY CONTEXT

Project Isizwe has encountered little regulatory resistance given that it uses Wi-Fi that operates in unlicensed bands. There are general challenges around Wi-Fi security that may become more significant issues

in future, such as if online payment or similar services are launched over the portal.

KEY LESSONS

- Requires progressive local government with a digital inclusion agenda: Free Wi-Fi is generally offered with the support of government subsidy. It will likely come from local governments with existing, or strong intentions to form digital inclusion agendas with a goal to improve access for the underserved.
- Strong hybrid model potential: Free access could easily be blended with other business models that help subsidize CAPEX/OPEX, e.g., blended paid Wi-Fi model (B2C) or sponsored content model (B2B).
- Security of equipment is a concern: Agents in urban areas cited security concerns with customers loitering in small store spaces while agents in peri-urban and rural areas did not cite security risks. Providers must be mindful of security concerns for network equipment.
- Integration with existing agent networks is a promising approach: Utilizing existing agent networks in rural areas, in this case bank agents, provides a pre-existing sales and distribution network.

Note: As of December 2016, the funds used by the city of Tshwane for Project Isizwe's expansion is under the process of review because the Auditor General disagrees with the procurement mechanism historically selected by the city. The city and Project Isizwe are now looking for new ways to provide funding, including running digital ads over the service.⁵⁷

57. <http://www.news24.com/SouthAfrica/News/ag-declared-tshwane-free-wi-fi-project-unlawful-irregular-mayor-20161215>

Rhizomatica

<https://www.rhizomatica.org/>

ACCESS INNOVATION: Microtelco/community GSM

DATE LAUNCHED: 2009

NUMBER OF USERS: 3,000 active users per month, 16 active networks

MARKETS LAUNCHED IN: Mexico

Rhizomatica is a regional telecommunications cooperative that enables communities in Mexico to own and operate GSM networks. They have also been lobbying for regulatory change on behalf of small-scale community networks, arguing for special dispensations from regulators to allow small communities to legally utilize GSM spectrum. Rhizomatica's customer is the community that collectively operates the network.

CONDITIONS OF SUCCESS

- Rural environments where mobile operators struggle to provide affordable network coverage.
- Allowances from regulators in order to use unlicensed spectrum.
- Strong existing community social structures that facilitate the community ownership model.
- Availability of open source software/hardware to build the community network.

TAKEAWAYS

- Regulators allow for use of unlicensed spectrum in Mexico: The Mexican regulator has allowed specific bands of GSM spectrum for use by microtelco/community GSM networks.
- Innovative business model elements are being tested: Rhizomatica have tested interesting adaptations of business models including subscription pricing and capped call time limits.
- Communities can operate their own networks at cost: Rhizomatica's larger goal is to find the

minimum amount of CAPEX and OPEX to run microtelco/community GSM networks, and then allow local communities to run networks at this cost level without margin.

- Microtelco/community GSM can be mobile operator agnostic: By using VOIP there is no need for a relationship with any of the mobile operators in the market, and there is no perceived friction with these players since Rhizomatica operates in communities where mobile operators choose not to operate.

ORGANIZATION HISTORY AND BACKGROUND

Rhizomatica was started by Peter Bloom in 2009 as a nonprofit to create a regional community telecommunications cooperative. There are now 16 active networks in Mexico with around 3,000 active users per month. The Rhizomatica team consists of eight people, split into three groups: the first group focuses on technology and building out software tools, the

APPENDIX 2: CASE STUDIES OF ACCESS INNOVATIONS

second group focuses on legal issues such as lobbying the Mexican government for legal access to spectrum, and the third focuses on working with communities to enable them to set up and independently run their own networks.

OFFERING

Rhizomatica's model focuses community ownership with the responsibility to run and maintain it. This model allows the community to have access to an otherwise unavailable local GSM network at an affordable rate. For a fixed monthly fee, local users can make as many calls within the local network as they want, as well as to any other Rhizomatica network. If users want to make long distance calls they can purchase credits, to make VOIP calls (e.g., to the United States).

ECONOMIC MODEL

The community finances the CAPEX and installation costs, around US\$10,000. They also cover the OPEX costs, which include power and backhaul. In terms of revenue, each user pays 40 pesos per month (~US\$2.40) as a flat "membership fee." Of these 40 pesos (less than US\$2), 15 pesos go to Rhizomatica to cover its operating costs, and 25 pesos stay in the community to pay for various costs, including electricity, backhaul, and occasionally a fee to the network administrator. The revenue model was co-designed with communities that determined that the most equitable revenue model was through subscriptions. Given the limited number of channels available on the network, the community decided that local calls could be no longer than 5 minutes, though long distance calls have no time limit.

OPERATING MODEL

Rhizomatica's ground operations ensure that

connectivity is in place for backhaul and remote management. They train local communities on how to operate, shoot, and manage the network. Rhizomatica's operations also include lobbying for spectrum and continuing to develop open-source network management software. Rhizomatica's free open source set of materials is available at GitHub.⁵⁸

PARTNERSHIPS

Rhizomatica partnered with the Shuttleworth Foundation for core financing, with the remainder coming from the Secretariat of Communications and Transportation of Mexico. In addition, Rhizomatica partnered with local communities to help roll out networks. Rhizomatica did not interact or partner with any mobile operator in the market.

MARKETING AND DISTRIBUTION

Rhizomatica does not actively market and instead relies on word of mouth to distribute their networks. Once the relationship with a community has been established, Rhizomatica helps network administrators run and manage their network but does not interfere with daily operations. Thus it is up to local communities to make new users aware of the service, but this is generally straightforward given the small size of communities in question.

TECHNOLOGY

Rhizomatica views licensed technologies as hindering innovation, which is why operating with open source software has been critical for Rhizomatica. Rhizomatica's own open source software is developed for the management layer of their solution, which others have taken on and adapted for use elsewhere (e.g., Nicaragua). Another reason Rhizomatica stresses the importance of open source hardware is a need to fix

58. GitHub. "Rhizomatica." Posted at <http://github.com/rhizomatica>. Accessed January 2016.

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locally; so if a network goes down, it is cheaper to fix locally than working with international manufacturers. A detailed documentation of Rhizomatica's hardware and software can be found on their wiki.⁵⁹

REGULATORY CONTEXT

When Rhizomatica started working in Mexico, the regulatory environment did not allow microtelco/community GSM networks like theirs to operate. Rhizomatica began to operate its network under a special dispensation from the Mexican communications regulator, IFETEL. As a result of its lobbying work with IFETEL, Rhizomatica was awarded with regulatory change that set aside 2 x 5MHz of spectrum in the 800MHz band, for "social" use. The criteria are that the communities being served must be under 2,500 people or be designated as an "indigenous region" or designated as a "priority zone." In addition to this work, Rhizomatica helped get the ITU to approve "recommendation 19"—a resolution that recommends governments ensure access to local participation in networks.

KEY LESSONS

- Lobbying for regulatory change can work: Through Rhizomatica's efforts, the Mexican government set aside two bands of spectrum for "social" use for microtelco/community GSM. Providers in other regions can learn from this success.
- Open source has been pivotal: Rhizomatica can work with open source free software; this is critical to their ability to operate. The reduction in cost lowers barriers to entry on the network infrastructure side and has been a critical enabler to microtelco/community GSM solutions. Those working in similar areas should review the opportunities afforded by

open source software/hardware.

- Most appropriate for rural: This solution is appropriate for locations out of traditional network coverage, especially where other infrastructure assets can be leveraged, e.g., satellite backhaul or power.

59. Rhizomatica Wiki. "System Architecture." Posted at http://wiki.rhizomatica.org/index.php/System_Architecture. Accessed January 2016.

Village Telco

<https://villagetelco.org/>

ACCESS INNOVATION: Community Wireless/ WiFi

DATE LAUNCHED: August 2008

NUMBER OF USERS: 6,000 devices sold

MARKETS LAUNCHED IN: South Africa, Columbia, Brazil, Puerto Rico, Nigeria, and East Timor

Village Telco sells a Wi-Fi-based mesh network device, Mesh Potato, to allow communities to build a mesh network that allows free local calls, long distance calls, and internet access. Village Telco's customers are the people within the communities purchasing the mesh network device.

CONDITIONS OF SUCCESS

- Local technical knowledge in communities to enable implementation, especially of more complex mesh systems (e.g., dual radio).
- High adoption of Wi-Fi-enabled feature phones and smartphones.
- Peri-urban environments with high enough population density to ensure short distances within the mesh network but lack existing network coverage.

TAKEAWAYS

- Mesh networks are typically community owned rather than commercial operations: Most known mesh network examples in emerging markets are community based, with few that operate commercially.
- Population density a constraining factor: The need for short distances between nodes in mesh networks make this technology ill-equipped to serve highly distributed rural communities, but can be appropriate for areas with greater population density (i.e., peri-urban).

- Investor challenges with open source projects: Village Telco is predominantly an open source project without any proprietary intellectual property (IP), which made it challenging to attract commercial capital.

ORGANIZATION HISTORY AND BACKGROUND

Village Telco is an initiative to build low-cost community mesh network hardware and software. It uses open source software and low-cost, Wi-Fi-based mesh networking technology to deliver affordable communications. Steve Song conceived the project during a fellowship and subsequent grant funding from Shuttleworth Foundation in 2008. At the time in South Africa, the ability to use traditional GSM networks was limited by access to mobile spectrum, but Wi-Fi could operate in unlicensed spectrum bands. This formed the basis for the Mesh Potato, a device that uses the Wi-Fi network for basic telephony services and internet access.

OFFERING

Village Telco developed the Mesh Potato to allow people to make free local calls on its network. Village Telco does not manage any deployments but rather manufacturers the technology for others to use. Most of the projects that use the Mesh Potato are small, with 10-100 service points, with the majority at the lower end of that spectrum, and operate on the fringe of existing GSM networks. Village Telco has sold about 3,000 of its first-generation device, and about 3,000 of its second-generation device. For the end user, the basic service will give them local, national, and international calling and internet (with local calls being free). The network required to deliver this is “plug-and-play,” i.e., users should be able to setup the device easily without technical assistance, and robust enough to withstand a variety of challenging environmental circumstances.

ECONOMIC MODEL

The original model was to generate revenue via hardware sales and, with a substantial enough user base of Mesh Potatoes, transition to selling cloud-based services (e.g., cloud-based network management and voice services). From a user perspective, the Mesh Potato costs about same as any other Wi-Fi router, US\$39.

OPERATING MODEL

The Village Telco operation largely spanned software and hardware development. The team designed and manufactured the Mesh Potato product, open source software, and documentation available to end users. They then distributed these devices at a retail price to users in markets where there was interest.

PARTNERSHIPS

Partners have generally helped Village Telco find communities to use their product or to promote their

work. Partners include NetworkTheWorld.org, Dabba Networks, David Rowe–Free Telephony Project, Atcom, Freifunk, Meraka Institute, IT46.se, and International Development Research Centre.

MARKETING AND DISTRIBUTION

In terms of customer channels, the marketing plan was to work through word of mouth and through value-added resellers, e.g., VOIP providers in countries like South Africa and Argentina. Once adopted, customer relationships can be managed online using the Village Telco wiki.⁶⁰

TECHNOLOGY

The current Mesh Potato is a mesh Wi-Fi router with a single FXS port (FXS is a telephone interface that supplies power, dial tone, and generates ringing voltage) and one 10/100Mbit Ethernet port. An analogue phone connects to the Mesh Potato via the FXS port. Nearby Mesh Potatoes automatically form a peer-to-peer network, relaying telephone calls without landlines or cell towers. The Mesh Potato hardware and software are open source. When making a phone call, the nearest Mesh Potato talks to the next closest, which talks to the next Mesh Potato, and eventually to the destination. The mesh network can be augmented via links to internet backhaul, which allows for other services, e.g., VOIP calls and internet access. One server is needed to provide billing and dashboard services for an administrator. These services can be run on a standard laptop computer. Scaling mesh networks is challenging, since the number of nodes in any given network is limited. Wi-Fi devices work on a “listen before talk” basis, e.g., given three adjacent nodes in a network; the middle node cannot concurrently listen and talk to nodes either side of it. It is possible to overcome this challenge with a dual radio, which can simultaneously

60. Village Telco. “Village Telco.” Posted at <http://wiki.villagetelco.org>. Accessed January 2016.

listen and talk, but it becomes challenging for local network owners to implement. Village Telco has developed a simple management dashboard that manages and monitors billing, reporting, and usage statistics that can help network operators manage and operate their networks.

REGULATORY CONTEXT

There are no major regulatory hurdles to the model since Wi-Fi utilizes unlicensed spectrum bands.

KEY LESSONS

- Device sales business model: Village Telco struggled to succeed with a purely device-sales-based business model, largely due to the challenges of training local implementers to setup, maintain, and commercialize their own networks. Aligning business models to more clearly drive usage, e.g., a revenue share, may be more appropriate.
- Anticipate the need to address technical challenges as networks scale: Support in first generation mesh networks was poor for video and voice applications because of varying delay across the network. As a result, most mesh network providers have upgraded to dual radio. However, this is harder for local network owners to implement. Considering factors like these, providers must anticipate the need for skilled technical implementers when designing mesh business models.

ViRural Africa

<http://www.virural.com/>

ACCESS INNOVATION: Mobile network operator-partnered GSM

DATE LAUNCHED: Status – Pending

NUMBER OF USERS: 20,000 communities, 40 million end users (planned)

MARKETS LAUNCHED IN: Nigeria, Liberia, other undisclosed markets (planned)

ViRural Africa is focused on extending ICT services to underserved rural communities in Africa. ViRural Africa's strategy is to target communities with adult populations greater than 2,500 that have no access to power, no cellular coverage and no internet access. This approach focuses on providing either a managed service for one mobile operator, or wholesale network service for multiple mobile operators in rural, underserved areas. ViRural Africa's customers are the mobile operators.

CONDITIONS OF SUCCESS

- Markets with healthy mobile operator competition.
- Mobile operator partners who allow access to spectrum.
- Wholesale and infrastructure sharing models must be allowed by the country regulator.
- Rural environments where mobile operators struggle to provide affordable network coverage.

TAKEAWAYS

- Managed services as a means to extend last-mile mobile operator networks: Managed services, where a network vendor builds and operates the network, are an attractive business model for mobile operators who are not willing to spend the CAPEX to build last-mile networks.
- Managed services versus wholesale models: Policymakers need to better understand the commercial dynamics behind advocating for wholesale networks where multiple operators use the network, versus managed services where only one operator uses the network.

ORGANIZATION HISTORY AND BACKGROUND

ViRural Africa is a for-profit venture, aiming to rapidly scale rural network infrastructure in partnership with mobile operators across rural communities in African markets. The background of the founding team spans the technology, telecommunications, and finance sectors. The original founder Paul Talley became interested in Africa five years ago when taking a role with a capital mobilization platform for infrastructure investment opportunities, Zanbato. Through these experiences, Paul saw an opportunity to address disparity between rural and urban connectivity in Africa through low power, OPEX and CAPEX GSM cell towers. Paul formed ViRural Africa, a company with operating subsidiaries in the United Kingdom, Nigeria, and other target markets. The C-level team is distributed globally, with technical consultants in the United States and local target markets.

APPENDIX 2: CASE STUDIES OF ACCESS INNOVATIONS

OFFERING

ViRural Africa's primary customer is the mobile operator, where it allows the mobile operators to extend their network into small rural communities. ViRural Africa finances, builds, and operates the network on behalf of either one (managed services) or many (wholesale) mobile operators. Rural communities benefit from having mobile phone coverage, electricity to charge their devices, and access to a Wi-Fi hotspot near the ViRural Africa towers. ViRural Africa is active in several African markets, with a focus on Nigeria with a goal to connect approximately 20,000 rural communities and provide connectivity to 40 million people.

ECONOMIC MODEL

Through a revenue sharing agreement with ViRural Africa, mobile operators are able to gather new subscribers, and receive more revenue from existing subscribers. ViRural Africa generates revenue in four ways: one, a revenue share when a participating mobile operator subscriber uses a ViRural Africa tower to make calls, send messages, and use mobile data; two, Wi-Fi services for the community; three, device charging at the ViRural Community Hub; four, pay-as-you-go solar power for the home.

OPERATING MODEL

ViRural Africa provides both passive (towers) and active (radio equipment) infrastructure for wholesale access by multiple partner mobile operators. This is often described as an "upside down MVNO" (mobile virtual network operator) because the MVNO has subscribers but no infrastructure, while the wholesale network has infrastructure and no subscribers. The main challenge here is that mobile operators prefer not to share the active radio network. An alternative to the wholesale model is managed services, where a network vendor deploys sites for a single mobile operator. ViRural Africa will likely take this approach in Nigeria,

where the Nigerian Communications Commission currently prohibits the sharing of active infrastructure.

PARTNERSHIPS

For their business to work, ViRural Africa must find a mobile operator to partner with. Once the rural communities have been selected for deployment, ViRural will design and construct the local towers and infrastructure.

MARKETING AND DISTRIBUTION

After constructing their cell tower, ViRural Africa installs a 40-foot shipping container that serves as a community hub. The shipping container houses the equipment and solar panels. ViRural Africa provides power, communications, and a structure to a tenant seeking to occupy the container. There are a great many ways in which these containers may be used to benefit the small rural communities. They might become local markets, schools, internet cafes, eHealth clinics, training centers for young entrepreneurs, vocational training for women, or hubs for NGOs.

TECHNOLOGY

Each site serves a distance of up to 10km and 2,500 subscribers, or larger populations by clustering sites. Power is from solar with lithium iron phosphate batteries, eliminating the need for diesel fuel. The technology is proven, certified by some of the world's largest cellular operators, and is successfully operating in rural communities. ViRural Africa does not use open source technology since they have seen major challenges in getting mobile operators to accept networks that are running on open source due to security, certification, and Quality of Service. Backhaul is provided using fiber, microwave, or satellite depending on availability in the geographic region.

REGULATORY CONTEXT

Since ViRural Africa's technology works within the standard 2G and 3G spectrum, they must gain access to the licensed spectrum via partnership with license owners (mobile operators).

KEY LESSONS

- C-level MNO buy-in is key: ViRural's summary of the challenges with MNOs to date is not "hitting the right level in the organization." The sensitivity to competition, perceived risk around new technologies, and aversion to revenue share models made pitching the solution to anyone under C-level a challenge.
- Open source presents certification challenges: ViRural does not see open source working in this industry because of the "certified box mindset," i.e., the use of proved and tested technologies within their networks.
- Wholesale network challenges: ViRural's aspires to roll out a wholesale network but is currently unable to because MNOs are resistant to infrastructure sharing; some regulators still prohibit infrastructure sharing.

APPENDIX 3: INNOVATIONS IN BACKHAUL

A key supply-side barrier to last-mile access is the challenge of extending the network to low-density, remote and/or low-income areas where traditional network operator costs outweigh potential revenues, particularly relative to higher density, higher income urban settings. A number of innovations are underway that have the potential to shift the economics of backhaul expansion, including both traditional fiber or microwave backhaul, as well as substitutes in settings where traditional deployments are not possible. In most instances, backhaul innovations are wholesale solutions that require partnerships with mobile operators, ISPs, or other service providers to reach end users.⁶¹

NEW MODELS FOR DEPLOYING OPTICAL FIBER NETWORKS

Given the high CAPEX costs of deploying fiber, it may be easy to overlook the potential of fiber-related solutions. Wherever possible, however, fiber is the preferred option for backhaul to support high-speed access networks. Although initial deployment costs are high, once installed, fiber offers high capacity that can be more reliable and faster than satellite or microwave options (assuming no service interrupts because of damaged cables). The high capacity possible with fiber supports the sharing of the backhaul infrastructure across multiple mobile operators and Wi-Fi operators. Fiber has low OPEX due to minimal power and maintenance requirements. Under the right conditions, it tends to offer a lower cost-to-serve for individual end users than alternative solutions.

Traditionally, mobile operators have tended to own their own fiber networks. As the digital value chain shifts, however, more examples of wholesale or shared fiber networks are emerging. By reducing the CAPEX required by individual operators, as well as allowing new entrants to gain access to fiber backhaul, innovation in the use of fiber networks has the potential to help governments and industry expand existing coverage and the market frontier as far as possible to the last mile. For example, since the majority of deployment costs arise from putting conduit and fiber in the ground or

installing fiber along poles and towers, governments can encourage more cost-effective fiber deployment by requiring that conduit to be included in all new road construction and ensuring communications firms access to power and other towers and poles.

LICENSE-EXEMPT SPECTRUM SUCH AS TV WHITE SPACE

One solution being tested for use across urban, peri-urban, and rural regions that lack affordable access is use of TV white space, which refers to the spectrum released when governments shift TV broadcasting from analogue to digital bandwidths.⁶² TV white space networks utilize spectrum that is unused in a particular location and at a particular time. TV white spaces exist between airwaves primarily used for digital terrestrial TV broadcasting in VHF (30 MHz to 300 MHz) and UHF spectrum bands (470 MHz to 790 MHz). Although, TV white space has applicability in rural environments, the principles of dynamic spectrum can be applied to other frequency ranges, suggesting the potential for greater innovation in its use in both developed and developing markets.

TV white space signals can travel as much as four times the distance of regular Wi-Fi, without additional power requirements, and can penetrate walls or other physical barriers more effectively than Wi-Fi. With additional power, it can achieve coverage akin to mobile networks,⁶³ making it particularly useful in rural

61. Satellite and other backhaul solutions can work directly with corporate clients, but are out of scope for the purposes of this paper.

62. TV white space includes VHF (30 MHz to 300 MHz) and UHF spectrum bands (470 MHz to 790 MHz).

63. Spectrum Technology page. Microsoft Research website. Available at: <http://research.microsoft.com/en-us/projects/spectrum/technology.aspx>. Accessed November 2015

APPENDIX 3: INNOVATIONS IN BACKHAUL

environments. In addition, TV white space base station radios are only 10 percent of the cost of LTE base station radios.⁶⁴

TV white space deployments require a supportive regulatory environment that allows for use of this spectrum. Generally, only large, established technology players such as Microsoft and Google have access to the resources required to lobby for such regulatory support. Markets with widespread adoption of Wi-Fi-enabled handsets, i.e., feature phones and smartphones, are required.

Although TV white space base station radios are only one-tenth the cost of LTE base station radios,⁶⁵ user receiver equipment is still expensive and perhaps at this point more suitable for shared access, owing to low production numbers and few manufacturers. Recently announced projects will further drive down the cost of receiver equipment, resulting in the production of access points and USB dongles.⁶⁶ Currently, TV white space handsets do not exist. Projects testing use of TV white space today tend to deliver services to end users either through Wi-Fi-enabled handsets or via shared access centers. With the launch of additional pilots, it is possible that receiver equipment production of access points and USB dongles will increase, enabling economies of scale for receivers.⁶⁷

SATELLITES

While terrestrial fiber is the most efficient, large-scale backhaul solution in most settings, the economics of extending fiber to the low-density, low-income rural settings are challenging. In addition to terrestrial microwave, an alternative is space technology. Medium earth orbit (MEO) and geostationary satellites (GEO)

are proven approaches to providing backhaul for service providers in rural areas, particularly where topological constraints such as islands or mountains make fiber deployment unrealistic.

Satellites remain expensive to deploy and operate, and offer reduced service quality relative to fiber; given the distances signals must travel, data transmission experiences delays and relatively low bandwidth, limiting satellite solutions' utility for voice or high-bandwidth applications. Another limiting factor lies on the ground, because satellite-enabled receiver terminals may be prohibitively expensive for use by low-income populations.

As a result of the significant cost structures and regulatory issues associated with use of satellites, only large corporations have experimented with MEO and GEO solutions. Examples of companies and partnerships are emerging to explore the utility of satellites to improve access and adoption in emerging markets, however. That said, the private sector satellite industry is experiencing a new wave of innovation among companies such as Blue Origin and Space X, both in terms of declining costs of deployment as well as increasing bandwidth throughput.

HIGH-ALTITUDE PLATFORMS (HAPS)

HAPs refers to a range of more experimental solutions for providing backhaul coverage to mobile operator or internet service providers in rural, hard-to-reach areas. HAPs solutions under discussion or being piloted include balloons, low earth orbit (LEO) satellites, solar-powered unmanned aerial vehicles (UAVs), or drones.

64. In a conversation with Garnett, P, DIAL Advisory Group (January 2016).

65. Garnett, P (DIAL Advisory Group), personal communication, January 2016.

66. Garnett, P. "Microsoft's affordable access initiatives – partnering for impact." Posted at <http://blogs.microsoft.com/blog/2015/12/17/microsofts-affordable-access-initiatives-partnering-for-impact/>. Accessed January 2016.

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APPENDIX 3: INNOVATIONS IN BACKHAUL

Like MEO or GEO satellite solutions, HAPs could, if proven viable, extend networks to areas where fiber and microwave backhaul makes little economic sense. Service likely would be delivered to end users through service providers using receiver terminals serving as Wi-Fi hotspots. Relative to MEO and GEO satellites, however, HAPs operate at lower altitudes, potentially resulting in lower deployment and operational costs, as well as faster data links, lower power consumption, and easier access for maintenance.⁶⁸

HAPs solutions present somewhat new regulatory challenges, in both developed and developing markets, since models for licensing and using spectrum in ways that complement and do not interfere with existing satellite and terrestrial licenses have not yet emerged. Given the level of effort and resources required to navigate the regulatory issues, thus far only large companies with substantial resources have begun testing such solutions.⁶⁹

HAPS: BALLOONS

High-altitude flotillas of balloons, pioneered by the Google Project Loon, have the potential to bring ubiquitous coverage to wide areas, if perhaps only for large corporations with the substantial resources needed to navigate the considerable technical and regulatory challenges.⁷⁰

Google, for example, has been forming mobile operator partnerships providing backhaul and widespread 4G-LTE coverage in markets such as Indonesia. The company has indicated that it can deliver high-speed data at 5 Mbps to mobile phones, and 22 Mbps to a receiver terminal.⁷¹

Users can connect to the signal directly from an LTE-enabled handset enabling mobility of use.

Balloons are best suited for rural regions with low population density, or island-based geographies with a dispersed population. Regulatory support is required to operate the high-altitude, unmanned balloons, and to utilize spectrum bands without interfering with existing satellite and terrestrial companies. Partnering with existing mobile operators provides access to cellular spectrum and avoids the need to build a separate sales and distribution network where users can connect to the signal directly from an LTE-enabled handset enabling mobility of use.

HAPs networks are still in an experimental, demonstration phase of development, however, and the regulatory, technical, and commercial factors are still undefined. The balloons currently stay afloat for up to 100 days so a continual recovery and re-launch operation will be required.⁷² Each balloon delivers a coverage area of 1,250 square kilometres⁷³ so a large number of balloons will be required for blanket coverage of a country, estimated as “many hundreds of balloons to cover Indonesia.”⁷⁴ If a ground receiver terminal is required, there will be a cost to acquire the terminal, and users will be limited to the range of the receiver terminal. To connect directly to the signal a sophisticated 4G-LTE enabled handset is required, limiting utility among potential low-income users.

68. For example, LEO satellites are available at 500 miles altitude and solar aircraft can fly at 12 miles altitude.

69. Simonite, Tom. *Alphabet and Facebook's Stratospheric Internet Plans Get Tangled in High-Altitude Red Tape*. Cambridge: MIT Technology Review; March 26, 2016. Available at: <https://www.technologyreview.com/s/601106/alphabet-and-facebooks-stratospheric-internet-plans-get-tangled-in-high-altitude-red-tape/>

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74. Solon, O. “Google installing hundreds of internet-enabled balloons.” Posted at <http://www.theguardian.com/technology/2015/oct/28/google-installing-20000-internet-enabled-balloons-in-indonesia>. Accessed November 2015.

HAPS: LEO SATELLITES AND SOLAR AIRPLANES

Another set of HAPs includes flotillas of LEO satellites (500 miles altitude) or solar airplanes (12 miles altitude) that promise to bring ubiquitous coverage to wide areas, particularly rural regions with low population density. They could either provide backhaul for existing GSM and Wi-Fi networks or be used in conjunction with a receiver terminal.

If successful, HAPs LEO solutions could provide blanket coverage including remote, rural areas, therefore, users gain access to communications in regions that lack network coverage. Facebook claims data transfer speeds using infrared laser beams of 10 Gbps,⁷⁵ but it is unclear how this would translate speed for users.

HAPs LEO networks are still in an experimental, demonstration phase of development and the regulatory, technical, and commercial factors are still undefined. Regulatory support will be required for both the operation of high altitude, unmanned aircrafts, and to utilize spectrum bands without interfering with existing satellite and terrestrial companies. As with other HAPs solutions, only large corporations have the resources to move such efforts forward. If a ground receiver terminal is required, there will be a cost to acquire the terminal, and users will be limited to its range.

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