GRETA BYRUM

Building Broadband Commons

Tools for Planners and Communities

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RETHINKING INFRASTRUCTURE

Planning for Broadband Systems

As networked technologies transform the places where we live, digital participation becomes ever more important for access to basic rights, services, protections, and opportunities. Yet a focus on urban technologies as a series of services, apps, and platforms often leaves out consideration of underlying physical broadband infrastructure. While the academic and institutional field of urban design and planning has traditionally not included planning for broadband systems,[2] it is increasingly clear that broadband is an essential service, and that urbanists, governments, organizers, and residents all have roles in ensuring that everyone has reliable access.

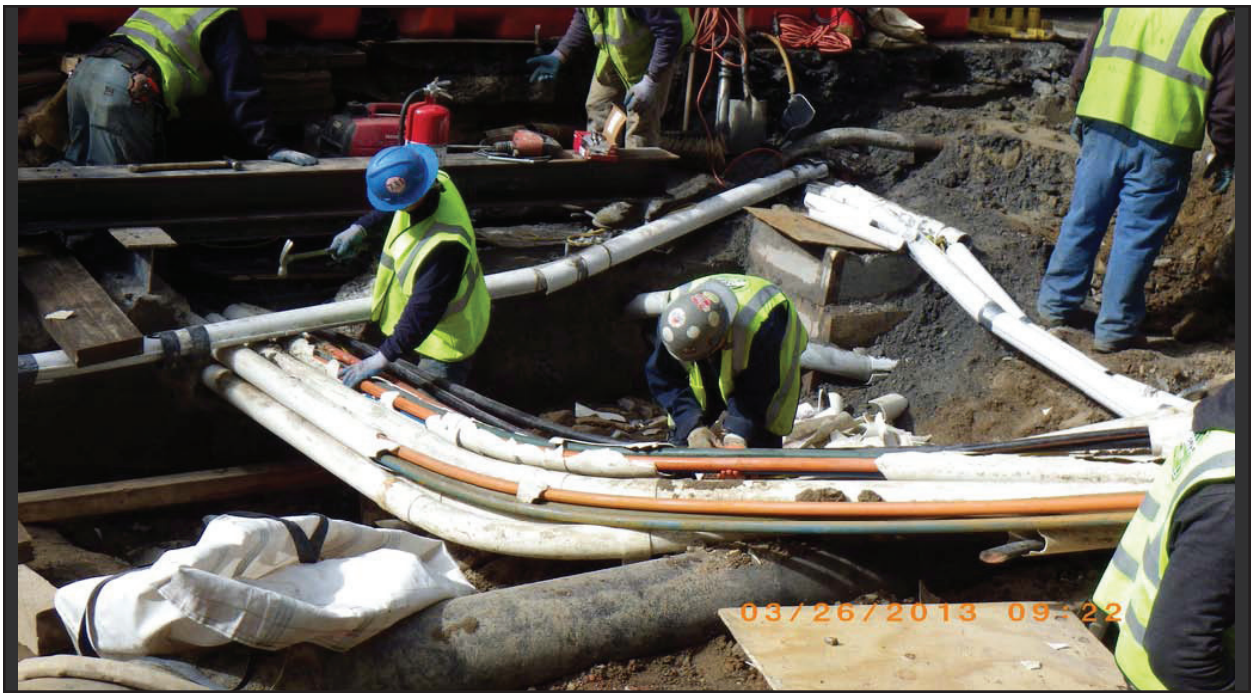
Yet with up to 28% of American households—primarily in underserved and traditionally marginalized communities—lacking reliable broadband connections at home,[3] inequitably distributed broadband resources can have a profound effect on many citizens' ability to participate in economic and social activity. While most digital inclusion policies and programs address individual choices around broadband adoption and digital participation, the design and distribution of broadband infrastructure itself is a fundamental element of equity—and in our digital society, a question of equal opportunity and basic rights.

So what roles should government, private industry, and civil society play in ensuring that all citizens have access to sufficient broadband services? Usually, broadband is considered to be either a private-sector service or a publicly-owned and operated utility. However, the growing prevalence of multi-sector, multi-layered approaches for other large-scale public systems suggests a different model. In particular, the fields of resilience and ecosystem services have produced a decentralized, participatory approach to addressing systemic issues such as stormwater management and disaster response and adaptation.

Meanwhile, many community-led networks around the world are already demonstrating a similar decentralized, cooperative "common-pool resource" approach to designing and building networked communications technologies.[4] This is not simply a fusion of private (corporate) and public (government) forces, but rather relies on community leadership, skills, and expertise. A community-led method of planning and provisioning broadband employs carefully managed partnerships, rebuilds the role of government and other institutions, and treats citizens as collaborators and experts on their own needs. As cities and towns work towards planning more collaborative, redundant, flexible, and ecologically adaptive systems in general, broadband infrastructure can be a site of pioneering resilience.

The Market-Led Approach

Historically, the U.S. has left broadband infrastructure build-out, ownership, and management to the telecommunications industry.[5] This approach runs the risk that some people may be left out of the digital sphere—either because the industry sees little potential return on capital infrastructure investment in certain areas, or because it has no profit incentive to price services at a rate everyone can afford. After all, the private sector does not have to answer to basic public obligations like universal service, as the government



Workers lay fiber lines in trench owned by Empire City Subway Company (a subsidiary of Verizon). Photo by NYC MTA

does. Currently, poorer census tracts in U.S. cities show Internet subscription rates far below the national average—as low as 20% of households subscribed—as well as disparities in available service speeds and cost.[6] [7]

At the beginning of the Internet era, the telecommunications industry mostly augmented its own existing telephone and cable systems incrementally to create broadband services. In recent years, however, those efforts have expanded to laying new high-capacity, high-speed fiber lines, as in the case of Verizon's FIOS and Google Fiber. For new next generation infrastructure like this, the industry tends to plan according to a supply-and-demand equation. For example, Verizon prioritizes FIOS build-out to places where there is an anticipated return on capital investment—neighborhoods where people are likely to subscribe to the more expensive service.[8]

Meanwhile, Google Fiber plans build-out to places where a certain percentage of residents contribute in advance to capital funding and commit to subscribing in the future. While the subscription threshold for Google Fiberhoods is not prohibitively high, in many underserved communities, residents are just starting to come online and may not be prepared to commit scarce income in return for the promise of future connectivity.[9] Google is taking steps to address these challenges, but cannot solve the equation for every municipality in the country—further, its incentive for serving the underserved is primarily corporate responsibility, not regulation or an official mandate to address this public problem. In this environment, next-generation solutions like fiber to the premises have tended to expand primarily in areas where people already have access and choice.

The State-Led Approach

Municipal or government-led broadband services provide opportunities for strategically aligned economic development and an array of structural options, as described in the Open Technology Institute's 2014 *Art*

of the Possible report.[10] Up until now, regulation has largely stood in the way of a widespread deployment of municipal broadband systems—though a few forward-thinking cities and towns like Cedar Falls, Iowa, and Lafayette, Louisiana have robust systems that can serve as models for other municipalities. A recent ruling by the Federal Communications Commission (FCC) preempted state laws preventing expansion of municipal-run broadband providers in North Carolina and Tennessee, but some local governments are still (for now) legally prohibited from building and owning telecommunications infrastructure.[11] [12]

Further, we can see from recent reports that public infrastructure in the U.S. is severely underfunded and a frequent loser in political battles.[13] Sunk capital investment in infrastructure is expensive and slow to pay off, with politically vulnerable, perpetually campaigning officials rarely in a position to see a benefit. (Who notices when the bridge *doesn't* fall down—or when the Internet *works*?) And overall, the expense and management required for a government-led approach is not feasible for all cities, towns, or counties. Local governments work with limited and constrained resources, especially when developing new areas of expertise and capacity. Further, cities must fit broadband systems and provisioning models into an already complex array of services and functions.

As a result of these challenges, private-sector broadband systems have dominated, creating privately-owned infrastructure that reduces choice in the marketplace and locks people into unevenly distributed and priced services. Thus, as the economist Joseph Stiglitz famously pointed out, in the U.S. we have been "socializing losses and privatizing gains,"[14] even when it comes to broadband. In this case, the losses include the opportunity cost of lost educational and employment opportunities, lost chances to close the digital divide and the opportunity gap, lost revenue for local businesses and entrepreneurs, and lost human and social capital, in addition to the lost potential revenue from public broadband systems.

The Flexible Approach

The falsely dualistic choice between state-led and industry-led efforts for broadband[15] —with neither model a clear winner—echoes a long-standing urban planning debate: the opposition of free-market non-planning to centralized state-led planning. Free-market experiments like the famously unzoned city of Houston are by turns held up as models of organically evolved social order or as tragedies of the commons. Meanwhile, an emerging group of thinkers and practitioners is demonstrating the potential of a common-pool resource approach, and is exploring how to develop community-led networks as a shared resource.

There are precedents for this model in other urban transformations. In the last decade, diverse groups of city, industry, and civic leaders in Medellín, Colombia have transformed the formerly notorious city into a paragon of cooperative multi-sector planning. Medellín's government convened carefully managed partnerships to prioritize multiple forms of community participation—an approach which has come to be called "social urbanism." The "commitment of all the citizens" plan—a common agenda that laid out policies and initiatives prioritizing the areas of greatest social and economic need—provided an outline for a set of successful demonstration projects and a series of public works in Medellín, mostly in areas that had the least resources and capacity.[16]

Meanwhile, here in the U.S., Philadelphia presents a case of re-thinking centralized forms of infrastructure systems planning. The city's outdated sewer system—like much of the nation's infrastructure—was crumbling a decade ago, causing a nasty brew of storm-water, raw sewage, and pollutants to flow directly into local waterways. But the city government couldn't afford to build a new system. So Philadelphia rolled out its "Green City Clean

Waters" plan in 2011: a 25-year effort to let residents take the lead in creating a web of small interconnected "green" infrastructure projects like roadside plantings, green roofs, porous pavements, street trees, and rain gardens, alongside training programs and STEM learning initiatives.

Thinking local—and integrating social engagement into systems planning—means reimagining infrastructure as we know it. The key to the "Green City Clean Waters" plan was building layers of community engagement and partnerships over technical and governance systems. Instead of building a massive new infrastructure project, the city government takes the role of offering funding and support to self-organized neighborhood groups as well as schools and libraries, enforcing building codes and requirements, and streamlining bureaucratic procedures. Already, the city has reduced the amount of stormwater flowing through its sewers by 80-90 percent, simply by stopping rain where it falls and allowing it to filter back into the ground.[17]

Could Philadelphia's approach to infrastructure, and Medellín's to social transformation, hold some lessons for other systems—especially for broadband, which is by its nature distributed and interconnected? There is a range of options for communities seeking the most appropriate broadband solutions, and networked technologies allow these solutions to evolve in a distributed and hybrid way. Just as every neighborhood has different assets and needs, there is no reason for every neighborhood to have the same broadband design or business model, though elements are portable and adaptable to multiple contexts.

Planning for Adoption and Resilience

In the following sections, we will define a set of tools that different actors—government, private sector, and community representatives—can assemble for broadband planning at different scales. Over the course of a series of demonstration projects, New America's Open Technology Institute has tested these tools to various extents, yet not

Community networkers install a rooftop node. Photo by Incite Researchers (flickr)

all in one place, at scale. This toolkit is not complete, but includes a number of key concepts and approaches that can be expanded as more leaders explore community-led broadband planning. This paper also builds on OTI's "The Art of the Possible" report, which provides an excellent overview of the components and requirements of physical broadband infrastructure as well as a set of tools for city governments considering their role in broadband provision.[18]

Yet more important than any particular tool or set of tools for planning broadband infrastructure is the principle of giving communities themselves the opportunity to lead. While it is essential not to over-promise on the potential of community-led broadband, we have faith in the ability of groups of committed people from multiple sectors exercising collective self-determination to shape tools and assets to fit their needs. The most important ingredient in this mix is not any particular technology, but—as in the case of Medellín—carefully managed partnerships and power-sharing agreements.

Further, we believe that it is necessary to look beyond traditional industry- or government-led efforts to address the issue of digital equity. All of these tools have been shaped together with our local partners in Detroit, Brooklyn, Philadelphia, and abroad, and with community groups we consulted with in New Orleans and San Francisco, who brought the benefit of many decades' experience working with local civic leaders and organizers. From them we have learned about the importance of in-sourcing skills, means, and tools from within communities, using demonstration projects as community-building opportunities, the pedagogy of popular education, and developing and following principles of digital justice.[19]

Contents

COMMUNITY NETWORKING

An Emerging Movement

Like urban gardens, local food coops, and local business associations or block clubs, community networks are self-organized, self-governed civic projects that add an important counterpoint to centralized service ecosystems. Advocates see them as a site for improving local resilience in a changing world.

These networks take all kinds of forms, from wireless mesh in neighborhoods to huge hybrid networks blanketing whole regions with a combination of DIY and "microtrenched" fiber, so-called air fiber, and wireless links. Many of them are run by hobbyists or tech evangelists who enjoy playing with software and hardware; yet some are started by aspiring techies or even non-techies who care about digital access and community choice in connectivity, or lack other alternatives.

A Short History of Community Wireless

One reason community networks don't get discussed much in the context of broadband access and policy in the U.S. is that there aren't very many operating at scale in this country. There are a few that have been around for a long time, like the Seattle Community Network with about 500 users, and newer networks that are growing fast, like WasabiNet in St. Louis and the Kansas City Freedom Network. In general though, community networks in the U.S. face multiple challenges.

In the late 1990s and early 2000s, after standards for wireless devices operating on so-called "unlicensed" Wi-Fi frequencies were released, a number of community networking efforts sprung up in the US, only to die on the vine. Some of them, like Wireless Philadelphia, tried to partner with municipalities and were shut down by the incumbent internet services providers (ISPs), which argued that government-provided broadband service amounted to an unfair market advantage.[20] Some community networks tried to use untested technology, which didn't work well enough in practice for people to rely on it for everyday basic service levels. Some networks failed because not enough people knew about them, or local residents did not know how to maintain and expand them, so there weren't enough users and maintainers to cover the basic needs for sustaining the effort. Unfortunately, the demise of many well-publicized early attempts at citywide networks—in Philadelphia, San Francisco, Seattle, and elsewhere—undermined the many promises officials and tech evangelists had made about their potential. Funders, city governments, and grassroots organizations came to see community networks as too much effort for the benefits they produced.

By contrast, it's in Europe and the developing world where community networking has really blossomed. For example, with about 60,000 users across the Catalonia region of Spain and current expansions into other parts of Europe as well as Africa and the Americas, guifi.net is the preeminent community network in the world. The Athens Wireless Metropolitan Network (AWMN), with about 5,000 users and new offshoots into rural communities in Greece, holds promise as a much-needed economic engine in the region. Wireless België, FunkFeuer, Ninux, and Freifunk are all demonstrating that there is a role for community

networking in the broadband ecosystem. While many of these networks were started to provide service in areas that lacked commercial offerings, they have outlasted the development of centralized broadband services, and continue to grow.

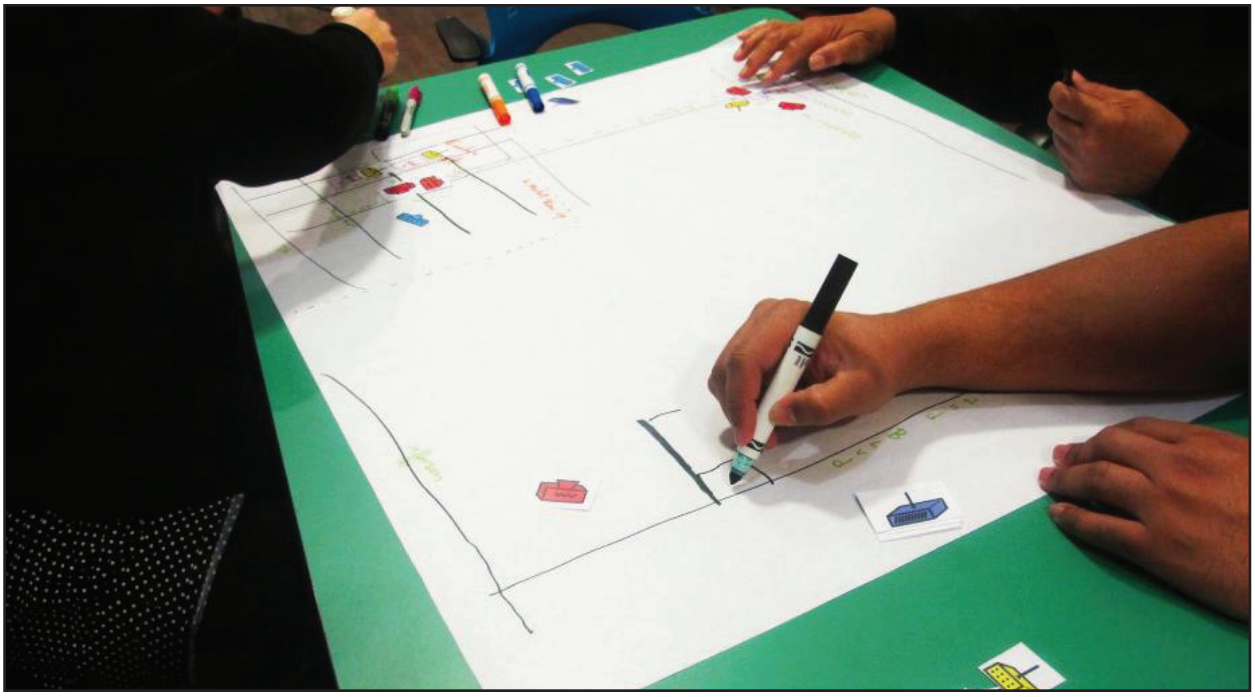
The European Commission has initiated a handful of research-based and prototyping efforts to understand and support these community networks. While some European networks started in the mid-2000s failed or were replaced by revenue-generating municipal projects, like Paris-SansFils, others have gone on to flourish as lively communities for technical and socioeconomic exploration. In some cases, such as AWMN's new rural partner Sarantaporo.gr, these networks are producing new models for local economic development and governance.

Pathways to Sustainability

Here in the US, New America's Open Technology Institute (OTI) has been engaged with multiple community networking efforts, many emerging from previous grassroots media organizing efforts -- for example, the ethos of community self-governance, barn-raisings, and local media organizing seen in the Philadelphia-based Prometheus Radio Project, documented by Christina Dunbar-Hester in *Low Power to the People*.[21] Further, our partnerships with Detroit's Allied Media Projects, with Philadelphia's Media Mobilizing Project, with Brooklyn's Red Hook Initiative, and with other community partners around the world, have deeply informed our work in the area of community technology.

With these partners, OTI has worked to find a pathway to sustainability. We did not want to replicate the same processes that has created "producers" (those with the technical knowledge and power) versus "consumers" (those who passively receive services and do not make choices about them). More importantly, we have tried to re-examine the assumptions that technology evangelists often bring—that technology experts should come from outside to drop the benefit of their knowledge in underserved communities, an assumption that tends to

Digital Stewards plan a network in Detroit, 2013. Photo by the Open Technology Institute



alienate the very communities who are meant to benefit. In view of the history of earlier networking projects, we did not want to initiate projects that could not be led, cultivated, adapted, and sustained locally. As journalist and community network documentarian Armin Medosch puts it: "far-sighted techies tend towards a linear extrapolation of technologies into the future without considering other factors, such as politics, the economy, the fundamental differences between people in class-based societies."[22] Similarly, Alison Powell's research on community networks points out their tendency to reinforce "geek-publics" rather than the "community-publics" they purport to serve.[23]

OTI's strategy has been to learn from community organizers who are taking the construction of broadband networks into their own hands using low-cost wireless technology.

By training local residents to be "digital stewards" of the networks, community organizers create employment opportunities and provide public Internet access while strengthening social networks within the community... At their most ambitious, these projects suggest a different way of thinking about work in the digital future: that we might manage our digital ecosystem with care and intention rather than constantly disrupt and respond to disruption. At minimum, these projects show the importance of localism and workforce development to maximize the economic benefits of new networks and produce technology that is attuned to a community's needs. (Joshua Breitbart) [24]

With leadership from our local partners, OTI has applied an approach of breaking community technology projects into all the pieces needed to make them sustainable: local knowledge and relationships, a holistic approach that takes into account the whole social/technical ecosystem, real value placed on listening and participating, and lastly, technical knowledge and tools.

The Commotion Construction Kit (CCK) is the first set of tools we co-produced with the Allied Media Projects (AMP) and Detroit-based social enterprise The Work Department, and piloted with partners in Detroit and Brooklyn. The training modules use Popular Education techniques to engage people of various technological and social organizing skill levels. The curriculum is designed to bring together multiple skill sets—technical, organizing, and hands-on—to build and maintain community networks as local resources. The networks function as active-learning projects for their communities to organize around.

Yet the Construction Kit—even as it is expanding into an open-source platform of community technology tools and practices[25]—does not go far enough yet in understanding not only how a network starts, but also how it scales up and offers an alternative to traditional broadband offerings. In order to inform next steps, we have gathered information by examining both our partner networks in the US and some successful European networks. These community-led efforts can provide STEM learning opportunities, drive local economic development, and enable governments to engage in increasing digital access in light-touch ways.

While research and compilation of current information on community networks presents many challenges—including the collective, non-hierarchical organizing structures of the networks themselves—the community does its best to document and share information.[26] The following samples just a few existing efforts and draws largely on groups that OTI has worked with, including members of the EU-supported CONFINE Consortium of community networks. While we are currently working on platforms for consolidated information-sharing, local efforts in the developing world are underrepresented in this sample.

COMMUNITY NETWORK CASE STUDIES

The Detroit Community Technology Project

The Detroit Community Technology Project grew out of Detroit Future Media, a Broadband Technology Opportunity Program (BTOP) project that trained Detroit residents in digital and media-based organizing rooted in the values of digital justice and existing local offline organizing networks.[27] Director Diana Nucera led development of the concept and pedagogy of Digital Stewardship, which was picked up by the Red Hook Initiative and is currently being expanded by several groups worldwide as well as the Open Technology Institute. The Allied Media Projects, home to the Community Technology Project, has trained three groups of Detroit Digital Stewards, who have started several new independent community networks with different designs and goals adapted to their home neighborhoods by residents.

Above: Detroit Digital Stewards install a chimney strap in the MorningSide neighborhood.

Right: Red Hook Digital Stewards install a node.

Photos by The Open Technology Institute

Red Hook WiFi

The Red Hook Digital Stewards are young adult residents of the New York City Housing Authority's Red Hook Houses. The Red Hook Initiative (RHI) has convened and trained three groups of Stewards, who have built and now maintain a resilient community network that serves this geographically separated low-lying Brooklyn community, prone to flooding and vulnerable to communication breakdowns. When Hurricane Sandy hit the Eastern Seaboard of the U.S. in 2012 and the neighborhood flooded, the network kept running as a lifeline to volunteer and donation response efforts, and also for a time served as a platform for the Federal Emergency Management Agency's operations in the area.[28] RHI is now exploring alternative and redundant energy sources for the network, with hopes of providing further STEM training opportunities for its Stewards.

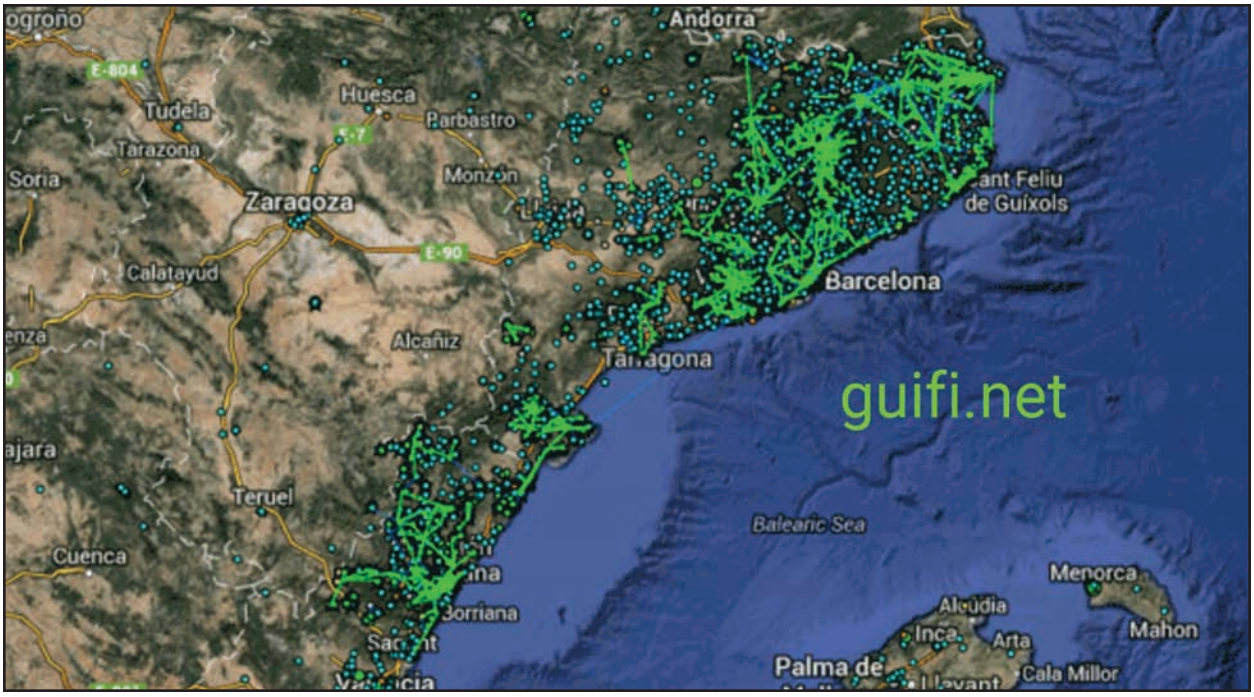
COMMUNITY NETWORK CASE STUDIES

guifi.net

Catalonia's guifi.net, currently the world leader in community networking with approximately 60,000 users and 25,000 nodes, operates on a wholly different business and service provision model than, say, Verizon does.[29] The network started about 15 years ago in an outlying exurb of Barcelona that lacked broadband service options. Though the area now has commercial offerings, the network continues to grow, even into major cities, and is now expanding to other parts of the world, including a partnership with the Free Network Foundation in Kansas City, Missouri. Guifi incorporates a range of different hardware and firmware and technology options, allowing different localities to adapt a system design to meet their needs and available resources.

Subscribers do not pay for bandwidth, but rather donate on a voluntary basis to the Guifi foundation. Local businesses, ranging from tech companies to TV repair shops and satellite dish installers, learn how to set up network nodes, harness the foundation's bandwidth, and set up service contracts with local users, then pay a percentage of their earnings back to the foundation. Local governments occasionally help kick-start the process by donating space on a hilltop for a big bandwidth pipeline to serve the area, or with a bit of start-up funding. Money does not flow to a big telecom conglomerate, but to local entrepreneurs and start-ups who do maintenance, troubleshooting, and computer help for local users, including local schools and community groups.

guifi.net has over 60,000 users and 25,000 nodes.



COMMUNITY NETWORK CASE STUDIES

Freifunk

Germany's Freifunk network started in Berlin and continues to grow there; there are also now Freifunk networks in several cities and towns throughout the country. Participants get involved via the meetup model, learning about the network through outreach efforts like YouTube videos and engaging in hands-on skills sharing. Freifunk's participants are mostly from technologically well-resourced communities, and have been able to produce much useful documentation of the process of setting up "mesh" routing protocols. Whereas many of the larger community networks use hybrid technologies to build easy-to-join systems, the Freifunk networks use a dynamic routing protocol, which is fully decentralized and resilient (it can route around node failures), yet which presents some challenges for throughput speeds and wireless interference. The mesh protocol is an embodiment of the network's principles of openness, as the Freifunk router firmware allows all users to anonymously join and share bandwidth if they wish.

Wireless België

Wireless België is one of the largest and yet least well-known community networks in Europe. According to participant and community network researcher Bart Braem, while Internet service is now close to universal and inexpensive across Belgium, the network has evolved as a versatile platform for technological experimentation. Networkers are currently organizing to fulfill a new mission related to the versatility and resilience of decentralized wireless communication systems. Belgium is home to a series of large music festivals; in 2011, 60,000 people attended a gathering near Brussels where a sudden storm hit, killing 5 concertgoers and causing chaos and panic. Resilient communication systems at festival sites could save lives in the future, enabling organizers to put out emergency bulletins and evacuate if necessary. Wireless Belgium is exploring ways to adapt its network as a resilient, decentralized platform which could be installed quickly at festival sites and would keep running even if major centralized networks experience congestion or failure.

AWMN

The Athens Wireless Metropolitan Network was one of the first decentralized community networks to operate at scale. Originally started as an alternative to expensive and unreliable commercial offerings, the network now covers most of the Greek peninsula and several islands, with new offshoots starting in many underserved rural areas. The new Sarantaporo.gr village network is documenting its process of building broadband infrastructure as a method of supporting local economic development. According to local organizers, villagers had not intended to create a network initially, but found that in order to build a community website they first had to ensure that locals could get online. With the new wireless network, young people are returning to the village and helping farmers and other local groups build cooperatives for sharing skills, and processing goods, and bringing them to market. With the Greek national economy experiencing a series of shocks over the last decade, local groups are increasingly interested in using technology to take economic development into their own hands.

RETHINKING GOVERNANCE

An Emerging Role for Local Government

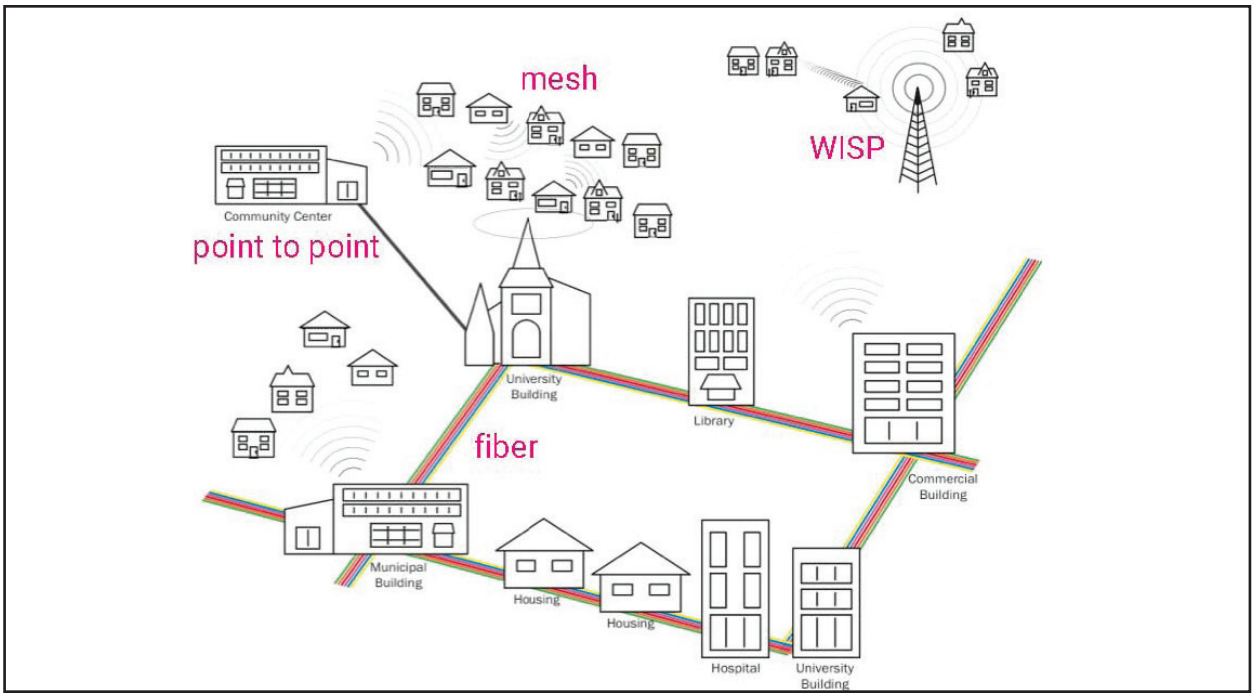
A community-led, multi-sector approach to citywide broadband infrastructure means building a citywide network piece by piece by coordinating infrastructure projects that may use different technologies, business models, and technical designs. While this may sound daunting as a way to create a basic infrastructure, it is actually the way that the Internet itself has evolved -- a process of distributed networks peering with each other to form one interconnected web.

As the leading example of such a network, guifi.net has succeeded by peering among heterogeneous and distributed social and technical structures. The Osono region, where guifi.net started —which in 2004 was ranked 31st among Catalonia's counties for broadband connectivity—is currently the only region in Catalonia meeting European Union targets for broadband connectivity. Guifi uses both wireless and fiber infrastructure, and employs mesh as well as point-to-point network architectures. It allows local entrepreneurs to set up chapters or service zones across its region, each offering to connect local users to a backhaul commons supplied by the Guifi Foundation, which also acts as a neutral institution monitoring the network according to a set of shared principles that all users agree to, the "The Compact for a Free, Open & Neutral Network."[30] Each professional service provider agrees to pay the Guifi Foundation a percentage of their earnings based on how much bandwidth they use, but local service providers can determine how they charge for services.

Thinking in this kind of multi-stakeholder, cooperative way offers an approach to broadband planning for city governments who may wish to innovate and take an active role in facilitating citywide access, yet do not have capacity or budget to pursue setting up, offering, and managing and maintaining municipal broadband systems. Instead, the municipality can coordinate and support multiple networks, and then create peering points among them or provide a transport network for backhaul.

In a system like this, because each neighborhood has different broadband assets and challenges, each sub-network may be different. For example, a university neighborhood could have a student-maintained mesh network drawing backhaul from the university's high bandwidth research network pipeline. Another neighborhood might already have its own community wireless network, which the municipality could support with a grant or a business development program. A downtown innovation district with a dedicated Internet trunk line could set up a point-to-point wireless link to create a hotspot in a nearby public housing complex. The municipal government could then create a program to train public housing residents to install routers throughout the housing development to provide broadband access in all units. Those trainees could go on to workforce placements in the innovation district or in other areas of the municipality that need broadband infrastructure.

Local governments can play a few key roles in coordinating and supporting a this kind of "network of networks" approach for broadband access. As with affordable housing, a mix of requirements on private sector contributors and public resources can generate citywide broadband assets. Regulation requiring open-



A new role for local government in broadband planning means coordinating among a network of networks.

access infrastructure systems and basic levels of service for broadband can further ensure that networks are interoperable and serviceable. Local governments can also institute and regulate enabling mechanisms such as tax-incentive financing for local projects and funding for STEM education and technology workforce development trainings.

Overall, planning distributed broadband means initiating and managing a series of distributed physical, social, and economic broadband planning measures. While some of these functions may fall naturally to a Planning or IT agency, local governments may wish to centralize broadband planning and coordination in one position or department, and to scale up as networks grow.

Convening, Facilitating, & Coordinating

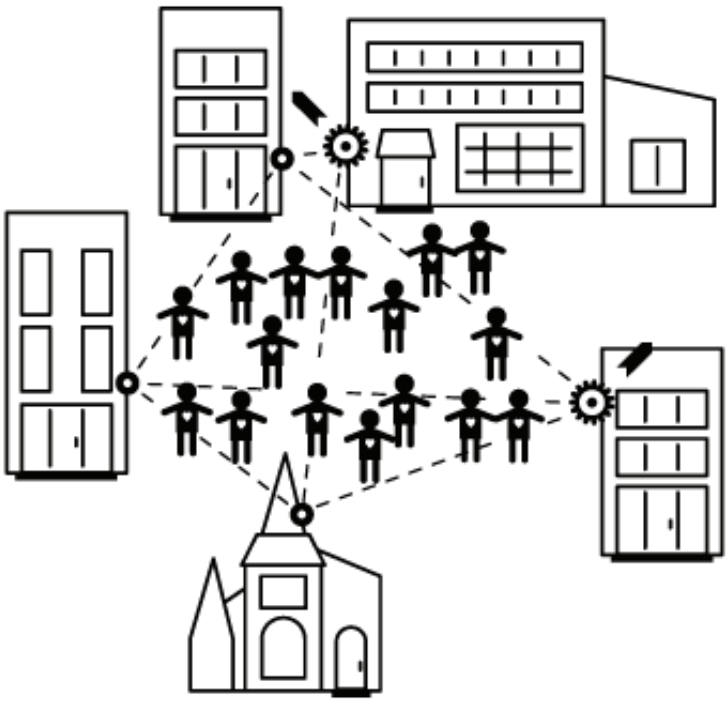
As central repositories of information about physical and social assets as well as cross-sector relationships, local governments have an important role to play in convening stakeholders. Municipalities can also ensure that city records on physical assets like dark fiber and open-access conduit and cables are digitized and available for all interested stakeholders. Many cities already have dark fiber or other networking resources, such as "institutional networks" connecting community anchors like libraries and schools or enabling smart-city technologies like parking meters or transit information. In most cases, these networks do not offer Internet service, but could be used as transport backbones for backhaul to different neighborhood networks.[31] Local governments can also facilitate access to resources such as research backhaul, educational spectrum, and rooftops that can be used for installing wireless links.

In addition, many cities and towns are also currently investing in "innovation districts," which purchase bulk bandwidth for resident institutional partners at wholesale prices. These backbones offer high-speed, high-capacity service, yet currently only universities, hospitals, and other big institutions can purchase this bandwidth wholesale. Local governments can play a

role in facilitating bandwidth sharing or purchasing for other kinds of community anchors, like libraries, social support organizations, and neighborhood coops. Local governments also have franchising power. They can divide their localities into manageable markets and contract with franchisees, and further can designate zones for tax-based broadband development incentives or loans to business improvement districts, or even to independent ISPs like BK Fiber or Sky-Packets.

A facilitation, management, and monitoring role for government has worked in other contexts. In the wake of Hurricane Sandy, New York City's PlaNYC has taken a distributed approach to resilience planning: "Working in partnership with a wide array of community partners and other stakeholders across the five boroughs, the City is pursuing a multi-layered strategy that will protect against a range of vulnerabilities."[32] Rather than planning and implementing every intervention, the City is facilitating a holistic series of physical, social, and economic resiliency initiatives. Some of these interventions are physical public works projects such as repairing coastal bulkheads, but the city has also funded several competitions, including pioneering resilience effort Rebuild by Design and economic development models such as the RISE: NYC competition, tapping into design, innovation, and technology communities from civil society, academic, and non-profit and private sectors. Further, the city has held multiple regional convenings and published several public awareness and toolkit documents, including "Retrofitting for Flood Risk," a guide for building owners grappling with new building codes, zoning guidance, and changing flood insurance realities. Finally, the City has established NYC Citizen Corps to bring together volunteer programs, community-based organizations, the private sector, and government to promote preparedness at the local level.

Bringing together experts from various sectors to facilitate partnerships allows municipalities to build capacity gradually. We recommend light-lift measures such as fellowship positions -- for example, depending on local conditions, a contractor or fellow working with Planning, IT, Economic Development, and Innovation



Local governments can work with an array of partners to develop a multi-layered approach to communications infrastructure.

Diagram courtesy of Commotion Wireless

Offices -- to coordinate these activities. This position can be funded via different sources, such as local foundations or state or federal programs. The broadband fellow would in the best case have a counterpart working in the civil society sector, convening and coordinating citywide to ensure that lateral coordination and knowledge-sharing across neighborhood networks is also taking place; a version of the Citizen Corps as in NYC's resilience plan could also take this role. This Community Broadband Fellow or Corps would act as a counterpart to the Municipal Broadband Fellow, convening grassroots stakeholders, creating Memoranda of Understanding, and heading up needs assessments and local engagement processes. The two fellows would work with each other using a version of the Collective Impact model, which recommends having a "backbone" organization that drives and guides the project (either the local government or a community-based organization).[33] Further, these fellows (or corps) could partner with local agencies and private sector firms to set up competitions and grants for innovations in broadband design and provision.

Depending on a local government's available resources and its planning timelines, it may wish to start with a series of small interventions over one or two years (for example, 2-3 pilot/demonstration networks, and a certain number of convenings). Getting a few working sub-networks off the ground quickly serves as a proof-of-concept and provides hooks for next phases of buildout.

Regulating, Monitoring, & Assessing

Local governments can also provide oversight in traditional areas of planning expertise related to identifying areas of need, mapping assets, and phasing distribution of the service. (See below, "TOOL: Methodology for Identifying and Addressing Areas of Low Broadband Adoption.") This central oversight function is essential for a distributed network of networks, to ensure that service is not uneven or inequitable across different areas or neighborhoods. Evaluation, documentation, and impact assessment can also drive future investment, as different parts of a network develop and expand.

Because in this model broadband infrastructure evolves as an interconnected network of neighborhood networks, it is important for the local government to operate in its regulatory function to ensure baseline levels of service across all sub-networks. Funding or access to assets could be contingent upon providing baseline levels of service by a certain date.

Regulatory power can also be used for ensuring that shared or city-managed resources are open-access and that information is shared about plans for construction. For example, a local government can set "dig once" policies that ensure that every time streets are dug up for construction or to maintain electric or other utilities, workers install open-access lines and shared conduit for multiple utilities. Further, the local government can ensure that all information about utility lines is shared in a public repository.

A broadband fellow or officer working with a municipality's agencies can develop a set of guidelines for properly assessing and regulating across a distributed network. This active function is an essential measure for achieving goals of equity across a municipality, especially where different neighborhoods have different levels of capacity and resources to contribute to broadband planning, and where the local government and its partners will therefore need to contribute different levels of assistance.

BROADBAND PLANNING TOOLS

It is a familiar refrain that public-private partnerships will create more efficient systems for providing goods and services, with less red tape and more entrepreneurship. Various tools and platforms emerging from tech start-ups are transforming not only our built environment, but the ways in which we communicate with our governments. Yet there are also warning signs that public-private partnerships may not always answer to public interest obligations, nor provide the same level of transparency and accountability, that is required of publicly funded efforts.

In January of this year, President Obama called for a new generation of public-private partnerships to build broadband infrastructure that is responsive to community needs. He highlighted some of the local networks that are demonstrating the many benefits of municipal ownership; and the National Telecommunications Information Agency also committed to providing a series of regional workshops to help localities build partnerships for broadband expansions and improvements.[34]

The following sections will explore additional strategies that local partnerships can use for building sustainable, locally-engaged broadband systems. These tools should be implemented alongside general best infrastructure practices like "open access" and "dig once" policies that require joint trenching of lines and coordination among agencies performing general maintenance, as described in the previous section.

Each of these broadband planning tools anticipates collaboration from multiple sectors. None of them is designed solely for government or private sector management, and all prioritize a role for local communities. If civil society has a voice in the way that service ecosystems like broadband evolve, it will provide important accountability functions, as well as ensuring that systems are appropriate and adapted for local conditions and needs. While public-private partnerships will likely never be regulated in the same way as government-provided services, community leadership and public transparency can help them evolve in a more responsive and resilient manner.

Community networks can re-purpose unused infrastructure.

Photo by the Open Technology Institute

TOOL: SPATIAL ANALYSIS

by Greta Byrum and Georgia Bullen [35]

Researchers can use this guide to compile geospatial broadband profiles including environmental and demographic data, local community assets, and available technical infrastructure; municipal agencies with limited resources to promote broadband access across a city can use it to identify areas of acute need and the assets to leverage for innovative solutions; community leaders who want to address a digital divide can use this approach to highlight inequity across neighborhoods, towns, or regions.

Broadband infrastructure is a part of digital ecosystems with both physical and social components. While consultation with residents is the only way to truly understand local digital ecosystems, analyzing standard indicators can inform local decision-making, facilitate analysis across communities, and guide planning on a city-wide or regional scale.

Broadband needs and assets vary across neighborhoods in a city. Successful projects account for those variations in their planning, either tailoring a solution to a specific community or considering the placement of resources as part of a larger region or set of projects.

Step 1: Identify and locate areas with broadband challenges

First, identify areas with low broadband adoption rates by examining census tract-level broadband subscription data and as well as locating environmental and demographic characteristics that are associated with lower rates of broadband adoption. This process helps determine priority locations for broadband access planning. The indicators below were drawn from academic and practitioner literature on the digital divide.

Broadband adoption data

> Federal Communications Commission broadband subscription data by Census tract
> Percentage of households adopting broadband services

Source: Aggregated data in tables and maps are available every six months under Local Telephone Competition and Broadband Deployment at transition.fcc.gov

Environmental factors

> High proportion of public/low-income housing
> High proportion of vacant land, abandoned/ condemned buildings
> Low number of commercial corridors, business improvement districts
> Low rates of owner-occupied housing

Sources: These data are generally available from local planning entities or open data websites.

Demographic data

> Traditionally marginalized race/ethnicity
> Less than average educational attainment
> Language other than English spoken at home
> Unemployment status
> Median income below a certain threshold
> Households below 100, 150 or 200% of poverty line
> Households receiving food stamps/SNAP/WIC etc
> Single parent-headed households
> Households with own children or others under 18
> Households with relatives or non-relatives 65+
> Non-family households with residents 65+

Sources: These data are generally available from the Census, American Community Survey, Current Population Survey, Bureau of Justice Statistics, Bureau of Labor Statistics, and other federal and local agencies.

Note: Vulnerable communities

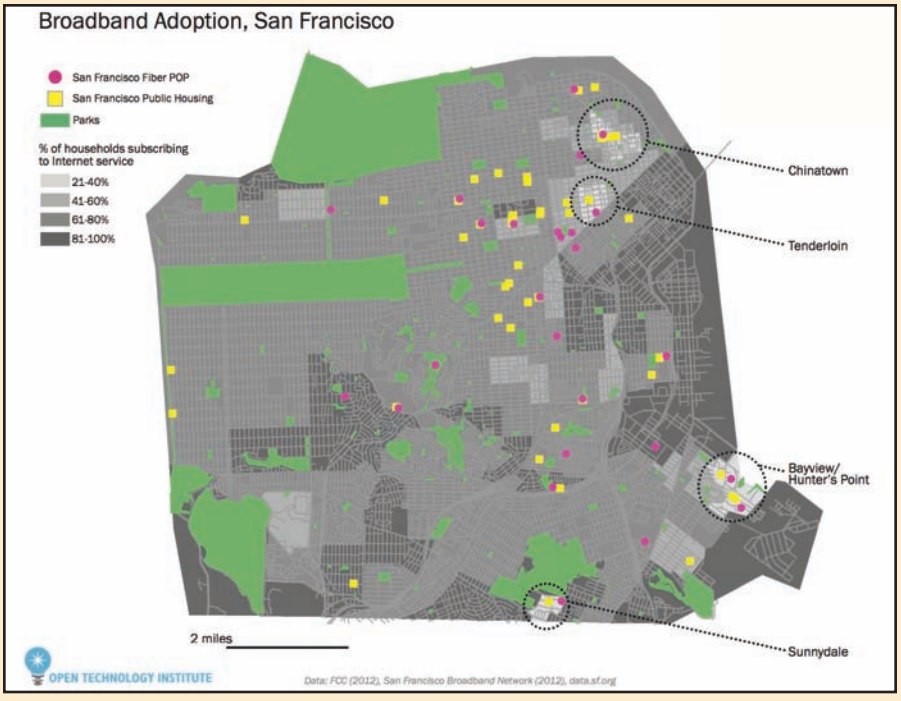
For communities that wish to plan ahead for disasters and unexpected events, it is particularly important to identify populations that are less likely to respond to evacuation orders, as characterized by:

> Linguistically isolated households
> Households with members 65+
> Caregivers for elderly relatives and people living with disabilities
> Transportation limited households

Mapping all of these datasets, and observing especially areas with overlapping indicators, can help to identify areas in need of intervention. Researchers may also choose to conduct a regression or a spatial regression to identify which specific variables most strongly predict low home broadband adoption. The data sets listed above can be used as independent variables, with the FCC's data on home broadband adoption by household as the dependent variable.

Wherever additional data sets on broadband adoption are available (such as market-research or Census data on home broadband availability), we recommend using them as well; the FCC data is only available in quintiles and at the census tract level, so for neighborhood-level analysis, finer-grain data is preferable. We also recommend joining the FCC data with land use and building data before performing a regression analysis, since areas with low density of residential uses (parks, industrial areas) may show either very high or very low adoption, due to small samples over large geographic areas.

Note: some areas where broadband service is widely available may nevertheless show very low rates of adoption. In many places where services are available but there are low rates of adoption, the problem may be with the cost of those services. The datasets listed above will allow for identification of populations that could benefit from broadband interventions; however, we would recommend further qualitative analysis and direct community engagement to determine whether, for example, the provision of low-cost broadband service or digital literacy training would be the most effective intervention in a given area.



Areas of low broadband adoption and broadband assets, San Francisco.

Map by the Open Technology Institute

Completing Step 1 will provide an overall picture of where broadband interventions should be targeted and whom those interventions should serve. The following phases outline the first steps in planning the interventions.

Step 2: Identify and locate broadband planning assets

The following types of organizations play an essential role in long-term sustainability of neighborhood technology investments. While many of these institutions and groups may not be focused on broadband specifically, they often recognize that expansion of access to information services is essential for their clients.

Community anchors
> Churches and faith-based social service institutions
> Community-based organizations, community centers
> Libraries
> Schools, educational, and workforce programs, including GED prep
> Social service facilities, including municipal aid and public/low-income housing
> Cooperatives (food, child care, etc.)
> Hackerspaces / Makerspaces
> Major bandwidth buyers including hospitals, tech firms, and universities

Other Points of Interest
> Public spaces (parks, plazas, etc)
> Commercial corridors
> Business Improvement Districts

While many of these institutions can be identified using land use and parcel data, tax records, and other open datasets, we also recommend local engagement to understand the network of social support that exists in every neighborhood. Facilitated neighborhood mapping workshops can generate nuanced local data.

Step 3: Identify and locate information infrastructure assets

Once you have a sense of where technological interventions may be helpful, and who within these areas can serve as anchors and sustainers, add a technical planning layer. This will provide a necessary baseline for deciding where and how to design broadband access projects. While some of this information may be available from federal agencies, you will need to do some fieldwork to scope out existing digital infrastructure and the physical characteristics of the terrain.

Existing digital infrastructure
> Wi-Fi networks and access points (closed and open)
> Dark fiber and other transport infrastructure
> Middle-mile or “bulk” bandwidth providers
> Network peering points
> Digital literacy programs/computer labs
> Hackerspaces / Makerspaces
> Areas with and without mobile coverage (provider-based and crowdsourced data)
> Areas with and without provider-based broadband service (National Broadband Map)
> Commercial Internet service providers (especially local or independent firms)

Technical planning data
> Building height, footprint data, notable high points
> FCC Antenna Registrations
> Potential alternative infrastructure (e.g., lamp posts)
> Terrain and elevation data

The data, maps, and other information gathered in this process can be used to identify areas for pilot projects and generate a timeline for scalable, multi-phase infrastructure buildout.

TOOL: LOCAL STRATEGIC PLANNING

by Greta Byrum and Darby Hickey

In recent years, urban planning projects and tools such as participatory budgeting have evolved to incorporate community feedback or input as a matter of common practice. However, public feedback mechanisms are usually framed as a discrete part of larger planning processes led by officials and experts, rather than opportunities for local groups to create a vision and a strategy to accommodate local goals and priorities.

Nevertheless, some neighborhood organizers and collectives of community groups do organize to create strategic local master plans. Rather than merely providing input, or stepping forward to play a role in initiatives designed by others, they are prepared to take a primary role and convene multi-sector partnerships to complement their efforts. Having a strategic plan and vision to unify efforts helps local groups work together to leverage tools such as community benefits agreements.

We recommend that coalitions of community groups wishing to work together—and any government or outside actor wishing to work with these coalitions —intentionally integrate a process to co-develop principles of engagement, such as an memorandum of understanding (MOU) or statement of principles. Diana Nucera's article on participatory civic technology, "Two-Way Streets," offers an essential guide for developing cross-sector collaborative working relationships.[36] The following section outlines, specifically, a guide to creating holistic neighborhood-based strategic plans that incorporate technological tools.

Strategic digital plans identifying key digital assets can help focus local digital stewardship efforts and get more people engaged in creating healthy neighborhood digital ecologies. They can also encourage people to get involved in the process of building equitable broadband infrastructure. The more that local residents are involved in choosing the technologies and the business models used in their neighborhoods, the more useful, relevant, appropriate, and sustainable neighborhood broadband technologies can be.

Strategic planning provides an opportunity for neighborhoods and local groups to set an intentional course for a healthy digital future. The economic potential in the digital sphere ranges from job creation to building local tech-oriented workforces for neighborhood needs.

We were inspired to develop this planning tool by the local New Orleans community group Tremé4Tremé, which conducted comprehensive community outreach and surveying to create a holistic and compelling strategic neighborhood plan.

Integrating Digital Resources into Neighborhood-based Strategic Planning

While technology alone cannot solve long-standing community or economic problems, digital tools can play a critical support role. Digital access and literacy can strengthen and extend existing on-the-ground efforts to improve opportunities for economic inclusion and community development.

A holistic approach to strategic planning proposes economic opportunity strategies to complement development plans and investments. Residents should identify a strong set of assets and opportunities in the neighborhood, with common threads running through sections on different economic development

opportunities, such as arts and culture, small business and entrepreneurship, housing development, building wealth, and public space planning. Dynamic interaction among these elements can create the basis for economic development. In particular, digital interventions can strengthen the interconnected threads among opportunity sectors, binding them more closely so that they all reach their full potential. For example, a local website that promotes arts and culture in the area can feature the work of a local artisan who has a vending permit for events in one of the public spaces.

Overall, incorporating digital components into a strategic plan can bind parts of the plan together; help to connect across people and places in the neighborhood; and link the plan and activities to surrounding industry and housing dynamics. Following are some elements that local groups can incorporate into their strategic planning process.

Wi-Fi in public spaces

> Wireless coverage can increase use of public spaces
> Wi-Fi can be an amenity itself and support other amenities offered in public spaces such as live music
> Vendors (as in a farmers' market) operating in public spaces can benefit from wireless access to the Internet
> Connectivity can allow web-streaming (video or audio) of events
> Wireless network maintenance can be an opportunity to support the development of a local tech workforce

Neighborhood Web Presence

> An online presence can showcase event schedules, restaurants and businesses, cultural sites, and the history of a neighborhood
> An online presence can be enhanced by bloggers or community documentarians
> Local entrepreneurs and artists can showcase their work online
> A neighborhood website can include streaming of music and other events
> Archives of recordings of past events can promote neighborhood arts and culture

Building Wealth Cooperatively

> Local groups can create a web presence for community and economic development efforts
> Local groups can create online job and training opportunities listings, in collaboration with local universities and employers
> Training programs can offer opportunities to incorporate digital literacy for a digital workforce
> Trainees can become consultants to help new and established local businesses build digital presence
> Trainees can also be developers of local web or mobile apps, such as for self-guided tours, reporting community problems, linking residents to services, and more

Organizing Digitally to Participate in Local Development

Access to digital tools can help neighborhood residents, businesses, and organizations ensure that development projects proceed according to community desires.

In housing development, fair access to digital resources as utilities is critical, and should be a requirement for any new housing projects in the area. A community can organize to ensure that developers and project funders commit to competitively priced, sustainable, and durable communications infrastructure for the long term. Installation of telecommunications infrastructure is an important opportunity for workforce development. It should be included in all conversations and agreements about design, planning, and contracting.

Digital tools can also help homeowners, renters, and residents broadly to organize and improve their neighborhood. Inclusive community email lists, a community website like Angie's List, and timebanking are all possibilities afforded by widespread home broadband access.

TOOL: LOCAL STEWARDSHIP

While community-led networks still face organizational and regulatory challenges, networking technologies are increasingly within reach for neighborhood associations or cooperatives wishing to sponsor or build hotspots, develop resilient emergency communication systems, or share connections to the Internet. [37] Municipalities and funders that want to see more of these projects can fund them or support them in partnership with local organizations as STEM education or workforce development initiatives.

One example of a locally grounded model for broadband workforce training is the "Digital Stewards" approach. Many of OTI's community partners are already training local residents to be Stewards of their own self-governed networks, creating employment pipelines while also strengthening local capacities and resources. Local Stewards who are engaged and invested in their neighborhoods' digital ecosystems are more likely to manage them with care and intention than large institutions or corporations that may not have such a strong stake. These projects show the importance of building human resource capacity to produce technologies that are attuned to a community's needs, and to leverage them to best advantage.

Digital Stewardship relies on a number of different skill sets. Stewards are not just technologists, but also organizers, teachers, artists, technologists, tradespeople, designers, etc. They may already work on digital justice issues in their community, or they may simply see technology access as an important part of other work that they do. OTI has partnered with the Allied Media Projects, the Red Hook Initiative, and groups around the world to develop the concept of Digital Stewardship through local technology projects that emphasize self-governance, resilience, and sustainability. We have worked with some partners to integrate a Digital Stewards approach into existing projects, missions, and goals, while in other cases local groups have independently used the toolkits that we and our partners publish as open-source resources.[38] This approach and the tools follow the principles of digital justice: participatory learning, research, and assessment methods; new, open source technologies; and inclusive models for engagement and organizing.

Local Digital Stewards training programs take a variety of different shapes, depending on local assets and capacities. All of the following models are related and interconnected, with different features emerging over time as community needs and visions evolve.

Digital Stewards in the Democratic Republic of the Congo plan a network.

Photo by Mesh Bukavu

Digital Stewards in Sayada, Tunisia discuss their networking plans. Photo by the Open Technology Institute

Community Organizing

Detroit's Allied Media Projects (AMP) first developed its Digital Stewards program to build neighborhood communications infrastructure as part of a citywide Digital Justice campaign. Digital Stewards are currently building wireless networks and developing local applications in seven Detroit neighborhoods.

Workforce Training

The Red Hook Initiative (RHI) in Brooklyn, New York created a Digital Stewards program as a workforce training program for young residents of nearby public housing. The Stewards work on the Red Hook WiFi network as a learning tool, also producing and hosting local content to serving the Red Hook community. The network also proved to be an important local asset during response and recovery efforts after Superstorm Sandy, and the City of New York funded the next group of Stewards to further develop resilience approaches and tools.

Open Governance

CLibre in Sayada, Tunisia built a wireless network to increase the civic mobilization around access to municipal information like the town's budget. These Stewards did not connect the network to the global Internet, choosing instead to use it as a local intranet tool for participatory self-governance.

Education

Digital Stewards at the Abaarso School of Science and Technology in Somaliland and Tamarind Tree School in Dahanu, India used OTI's tools to work with students to build networks connecting classrooms, dorms and public spaces to host educational applications and shared files.

Community Media

Digital Stewards from Radio Bukavu in the Democratic Republic of the Congo built a wireless network to expand and supplement the organizing work they have already long been doing with their local radio station.

TOOL: OPEN INFRASTRUCTURE

by Greta Byrum and Andy Gunn

Shared open-access conduit, fiber lines, and other hardware and equipment enable peering and sharing of network resources. Further, if a local municipality invests in open-access lines, subways, and conduits, it can also rent out transport to private ISPs for additional revenue. For peering of different network types, we recommend that municipalities in their regulatory capacity require open access and interoperability for any new infrastructure.

State municipal broadband bans also in some cases prohibit municipalities from providing transport infrastructure for different local network operators and bandwidth providers—even if the municipality does not intend to provide broadband service. The FCC's recent pre-emption of laws prohibiting expansion of municipal broadband networks in North Carolina and Tennessee is an encouraging sign that federal regulation is beginning to favor local broadband efforts.[39]

However, open access principles are essential not just for municipal or public broadband infrastructure, but also within new developments, especially public housing. Below, we offer some guidelines for ensuring that residents of new developments have choices for broadband service, and that they can use local and independently-governed networks if they wish.

Open Infrastructure for New Development

New development, redevelopment, or retrofitting of housing developments open unique opportunities for creating better telecommunications systems. A small capital expenditure on telecommunications infrastructure allows developers and planners to configure more adaptable and innovative systems alongside other new construction and upgrades. Better telecommunications systems mean improved customer choice, sustainable design, and opportunities for the addition of amenities.

In many new developments, incumbent telecommunications providers are invited to design and perform installation of communications infrastructure at no cost to developers. In return, they receive an exclusive market share of resident subscribers.[40] This process presents several major limitations for long-term service sustainability and cost effectiveness. Residents do not have the freedom to choose a service provider, and often must subscribe to bundled services at whatever price is set by the provider. In addition, choices about equipment and infrastructure are determined more by the provider's needs than residents'.

Redevelopment and new development create unique opportunities to bring state-of-the-art infrastructure into public housing, affording residents greater access to services, resources, and amenities. This design can also create safer, more populated public spaces by enabling Wi-Fi with the simple addition of outdoor routers.

The following guidelines ensure that communications infrastructure is: open to multiple vendors, enabling consumer choice; adaptable for changes in technology, bringing down the cost of future retrofitting; and useable for innovative community technology amenities that provide opportunity and access to digital resources.

These guidelines ensure that equitable, fair, future-ready, and economically balanced choices can be offered to residents of public and affordable housing as well as market-rate developments. Finally, improved in-building

design improves speed and quality of service by allowing smart information routing among multiple devices in housing units.

Making these guidelines standard practice can help close the “digital divide” among different public and affordable housing developments. The long-term savings and the inherent opportunities make such a capital investment a very cost-effective way to create a major improvement.

General Guidelines

> Individual units should be wired for high-speed data access to communications outlets, in addition to the standard coaxial and phone outlets.

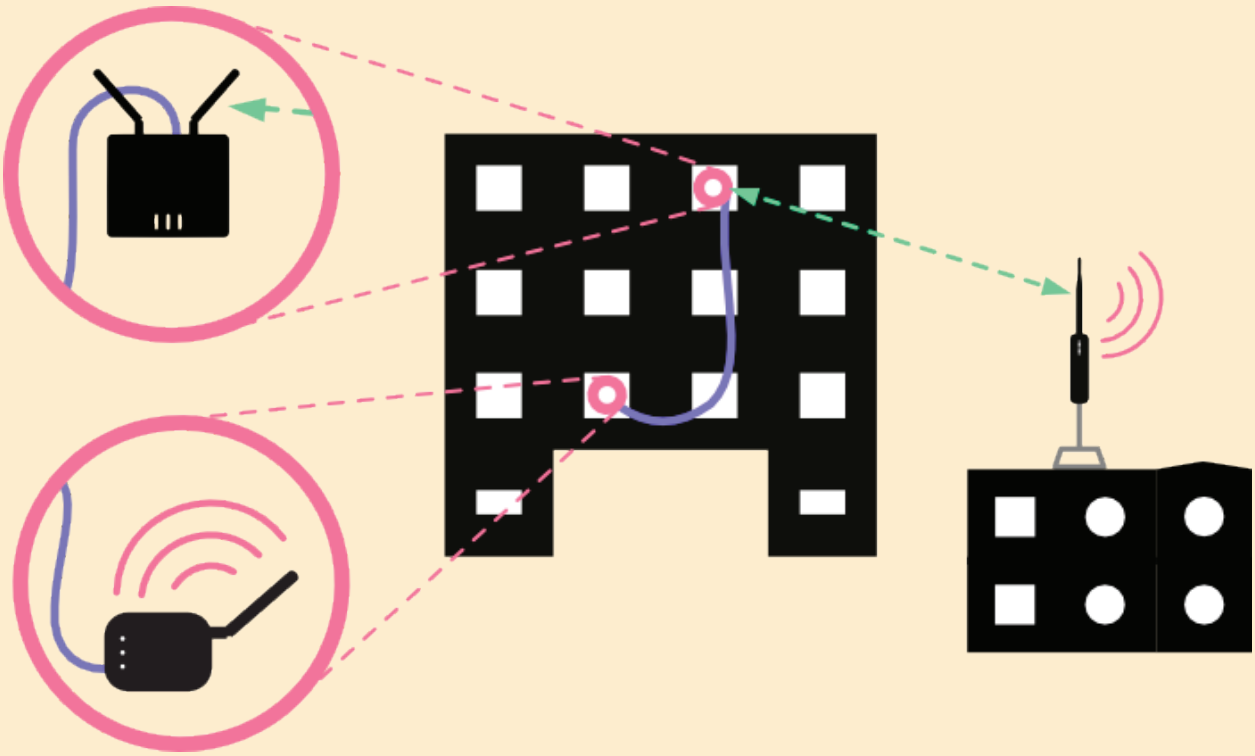
> Site-wide expansion and flexibility can be ensured by using conduit instead of simple buried wiring between buildings for distribution of service provider cabling. A centralized facility for service providers to access underground systems creates the opportunity for future-proofing.

> Conduit or raceway should run from each building’s communications room to each unit’s central phone, TV and data wiring panel.

Capital Costs & Future Savings

For approximately 250 units, the capital expenditure for open-access telecommunications infrastructure comes to approximately $250,000 - $300,000. This is a one-time expense which will keep residents from being locked in

Open infrastructure allows for addition of outdoor Wi-Fi coverage with the simple addition of rooftop routers. This can help close the digital divide among different kinds of housing, creating major improvements with low up-front captial investment.



to unnecessary bundled services, as well as give them the opportunity to shop around for more cost-effective service.

Communications infrastructure should be adaptable as technologies and data needs change. By contrast, with standard telecommunications installation models, future upgrades to fiber will require ripping out existing cables and completely rewiring the buildings.

For example, using Category 6 (CAT6) cable instead of the Category 5 Enhanced (CAT5e) normally used in standard telecommunications installations makes the up-front investment much more sustainable in the long term. CAT6 has an expected life cycle of 10 years or more, whereas CAT5e is recommended only for bare minimum, short life cycle installations.

Technical Specifications

These specifications assume a multi-dwelling unit (MDU). For each unit, we recommend at a minimum using Grade 1 residential telecommunications cabling to multiple outlets. This includes one two-pair telephone cable, one Category 6 UTP cable, and one 75-ohm Series 6 coaxial cable. Each outlet should have the corresponding RJ11, CAT6 RJ45 and F-connector for each cable. Paired fiber-optic cabling also recommended.

Each living area should be cabled with at least one telecommunications outlet. We define a living area as any room where voice, data or video applications may be used - such as bedrooms, kitchens, dens or offices, and living or family rooms.

The cabling from each outlet should run to an in-unit Distribution Device, with a co-located Auxiliary Disconnect Outlet (ADO) for each service. Trunk cables should run from the ADO in each unit to a Demarcation Point or Service Entrance in each MDU. This can be an outdoor cabinet or indoor telecommunications closet. The ADO cables should be run through appropriately sized conduit or raceway with ample room for future expansion.

For future outdoor wireless coverage, there should be additional enclosures installed on the outside corners of each MDU. If they are approximately 15 to 20 feet above ground, this facilitates complete area outdoor wireless coverage with the addition of access point hardware. Outdoor rated Category 6 cable should be run to the MDU's telecommunications closet and terminated in a patch panel.

Additionally, designing for pathways between buildings can facilitate unit-to-unit networking and future expansion or applications. If we treat this as a campus-style installation, a single Entrance Facility (EF) and Common Equipment Room (CER) in a main or central building can be utilized. In-ground conduit should be utilized to create pathways between the EF and each MDU's telecommunications room or service entrance. These should be sized for future expansion, and include the facility for multiple innerducts or micro-ducts for Category 6 and optical fiber between MDU's.

Access or Service providers should use the Entrance Facility to enter the campus, and distribute services to each building's service entrance.

TOOL: BANDWIDTH SHARING

by Greta Byrum, Andy Gunn, and Joshua Breitbart [41]

The high price of commercial broadband services, lack of choice in broadband offerings, and uncertainty about the possible benefits and harms of digital participation continue to keep many U.S. residents—both urban and rural—from digital participation. The problem of low rates of broadband adoption is particularly acute in historically low-income urban neighborhoods.

At the same time, downtown developments such as innovation districts and urban renewal projects often include newly installed telecommunications infrastructure, and are able to purchase bulk bandwidth at low rates. An innovative approach to our municipalities' connectivity challenges could be for well-resourced projects and institutions to collaborate with local stakeholders to share broadband connectivity. This approach could support underserved communities without prohibitive investment costs, increase community cohesion, and encourage more equitable, catalytic place-based development.

Step 1: Identify Key Anchor Institutions

Many urban communities with broadband adoption challenges are also home to strong communities and active grassroots organizations. Traditional "anchor institutions" in a community include schools, libraries, hospitals, and other stable economic engines. Yet many urban areas also have a set of formal and informal institutions that support their communities both financially and socially. These can include corner stores and barber shops in addition to local non-profits and government offices. Local hubs where people congregate to discuss neighborhood issues and share ideas are essential for building bridges to share goods and resources like broadband infrastructure. These are great places to install broadband hotspots, or to serve as the first points in wider neighborhood distribution.

Step 2: Partner and Plan

Neighborhood residents need more equitable access to broadband resources and employment opportunities; innovation districts and and urban renewal zones need good neighborhood relationships and a local skilled workforce. These needs and available assets can dovetail with an unorthodox solution: bandwidth sharing via wireless distribution links.[42] This is a less-expensive alternative to what would normally be necessary to increase speed and bandwidth for under-resourced communities—laying commercial fiber-optic cabling to local organizations and neighborhoods. Neighborhood organizers can reach out to developers, agencies, and institutions involved with new construction (or innovation district organizers and developers can reach out to local groups) to build relationships and plan for bandwidth sharing.

Once partnerships are built and solidified with an agreement such as a Memorandum of Understanding ensuring that all parties share the same expectations, the partners can begin to plan a technical design. Independent ISPs such as New York-based Sky-Packets are great resources for building unconventional broadband infrastructure.

Step 3: Implement & Document

Partners can contract out the technical process of installation to a local ISP or other implementer—essentially this only entails putting a few routers up on rooftops. However, it's important to keep communicating about how things are going and to document and monitor the network. This helps other communities set

up similar models, and also helps alleviate problems that might arise around bandwidth use or governance.

Estimated Costs

The below cost estimate includes two point-to-point wireless links operating within ~3 square miles between a well-resourced new development (such as an innovation district) and a local non-profit, enabling bandwidth sharing. The estimate also includes equipment and installation for indoor coverage at the local non-profit. It represents a one-time capital expense, and does not include the ongoing cost of bandwidth, which could be shared by the well-resourced new development without considerable additional expense.

	Equipment	Labor
Indoor Wireless	$6000	$6000
Backbone Links	$5000	$6000
Capacity Upgrade	$3000	n/a
Total	$14,000	$12,000

By contrast, the below cost estimate shows what commercial fiber-optic Internet access would cost the same local non-profit. These are dedicated service lines with high-availability Service Level Agreements. Note that for interior wireless coverage at the local non-profit, an additional $12,000 in installation costs would be necessary.

	Equipment	Labor
100 Megabit Access	$500-$1000	$1500-$2500
1000 Megabit Access	$1000-$2000	$5000-$10,000
Total		$61,500-$122,500

With a minimum of financial burden, a "do-it-ourselves" technological intervention can address digital needs and create a social connection among important anchor institutions. Neither partner is locked into a dependency. If either partner chooses to discontinue the relationship, all equipment can be uninstalled and repurposed.

If the cooperative relationship works well, however, both institutions can agree on terms for its continuation. Adding further links to other neighborhood institutions is also simple, at a much lower price than what is required for this first neighborhood link. This initial partnership can also lay the groundwork for future opportunities for collaboration in other areas, such as workforce development.

Bandwidth sharing reduces costs and binds neighborhoods together.

Photo by the Open Technology Institute

TOOL: DIVERSE FINANCING

A major benefit of community-led, distributed broadband planning is that it can leverage multiple and diverse funding sources. Whereas municipal broadband networks must use publicly restricted funds, and commercial telecommunications networks must follow particular supply-and-demand market revenue models for expansion, growth, and improvements, any number of financing tools can be employed to build distributed infrastructure. Following are just a few of the financing tools that can be harnessed across a broad municipal network-of-networks.

Public Financing

Tax incentive financing, public bonding, and allocated tax revenue are available for municipalities wishing to support local broadband.

Social Impact or Social Benefit Bonds

Often implemented as public-private programs, social impact bonds fund programs to perform. Ongoing funding depends on the ability of projects to meet benchmarks.

A Variety of Revenue and Business Models

Guifi.net is a great example of a heterogenous system that allows different business models to co-exist.

Federal and State Programs

Programs such as HUD and the DOE's Solar Powering America Home and HUD's CDBG-DR competitions provide funding that can be re-allocated by municipal governments for local competitions and projects.

Crowdsourcing

Many community networks crowdfund their projects, especially at the outset.

Cooperative Bandwidth Purchasing

Interested communities can pool resources to collectively purchase bandwidth, and either build their own sharing infrastructure or contract with local ISPs to do so.

Philanthropy

Local, regional, and national foundations interested in supporting community development, local economic development, and workforce training may fund networks as active engagement projects.

Corporate Responsibility Commitments

Private companies and developers -- either those with projects in local communities, or that wish to fund visible community development initiatives, may fund networking projects.

BECOMING RESILIENT

Increasingly, economists, urbanists, ecologists, and planners advocate for small-scale, locally adaptable, resilient systems and infrastructure. Elinor Ostrom argues that "institutional diversity may be as important as biological diversity for our long-term survival... for thousands of years people have self-organized to manage common-pool resources, and users often do devise long-term, sustainable institutions for governing these resources."[43] Community networks offer a case of uniquely hybrid, distributed, self-governed "commons" model of infrastructure design, fabrication, and maintenance. This infrastructure is infinitely scalable and lightweight, and like Bus Rapid Transit systems can be redesigned easily and cheaply as demand and other variables change, or deepened into more permanent systems as intensivity of use increases.

Currently, a lack of integration of social, infrastructural, and economic forces shaping broadband infrastructure has led to an inequitable system that puts reliable broadband access out of reach for too many. And industry consolidation and the resulting lack of competition among broadband providers has enabled telecommunications corporations to grow beyond public accountability. While many companies reap financial rewards from local communities for providing expensive and uneven services, they do not consult with local communities about their needs when growing and building infrastructure.

Thriving local network infrastructure offers models for addressing ongoing economic, social, and technological shifts. While centralized networks are often subject to cascading failures (as was the case during Katrina, Sandy, the Boston Marathon bombing, and every other major disaster in recent years), smaller, more distributed networks can keep going, especially if they are built using renewable and redundant power sources.[44] Small-scale, interwoven heterogeneous networks have already proven to be resilient and adaptable—with guifi.net leading the world by building a long-term, sustainable institution to govern the commons. Neighborhood-scale networks that use available, inexpensive equipment and local knowledge and skills can serve as training and organizing activities, building a community's service ecosystem holistically. Innovative planners and municipal governments have an opportunity right now to support such modular, resilient systems in light-touch and efficient ways, especially by engaging in carefully managed partnerships.

The European Union is future-proofing its Internet commons by investing in distributed innovation knowledge communities like the CONFINE project. In the US, whether we are able benefit from the advantages of decentralized networking depends upon many factors. For example, governments can help or hinder local self-organization. "Higher" levels of govemment can facilitate the formation of commons with legal definitions and structures as well as regulatory measures; local governments can facilitate the building of physical networks themselves, and academic institutions can facilitate the building of research and data commons. Community networks have the potential to create innovation from the edges, making our systems more inclusive, participatory, and grounded, providing a diversity of services and a diffusion of knowledge and innovation. Whether we get there depends on the choices we make now, and whether we have the courage to think differently.

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